BRIDGE CONSTRUCTION

GENERAL SPECIFICATIONS

NATIONAL BOARD OF PUBLIC ROADS AND WATERWAYS 1968

NATIONAL BOARD OF PUBLIC ROADS AND WATERWAYS

BRIDGE CONSTRUCTION
GENERAL SPECIFICATIONS

LIST OF CONTENTS

1: GENERAL DIRECTIONS

1:1 Scope of Specifications

These Specifications have been drawn up for the bridge construction works of the Finnish National Board of Public Roads and Waterways to be applied in bridge works carried out both by contractors and by the Board. When applicable, these Specifications may be used in constructing other similar structures.

1:2 Documents

These Specifications include the general quality requirements for the final result of work, construction materials, structures and working method. Similar regulations and instructions are also given in Standard Specifications of the construction field. Directions and instructions confirmed by the State Council or the Ministry of Communications and Public Works as well as acts of law and statutes of the Republic of Finland shall prevail over these Specifications. Unless otherwise provided herein the Standard Specifications and comparable instructions prepared by RIL and other organizations but not officially confirmed shall be followed.

The Bridge Plan consisting of Drawings and if necessary of Supplementary Specifications for the bridge concerned and of any other descriptions of the work shall indicate the dimensions and construction materials of the structure and

any special regulations concerning the working method etc. The Bridge Plan shall prevail over these General Specifications..

In addition to Documents mentioned above regulations and instructions (among others, permit conditions stipulated by Water Court) issued or delivered by the National Board of Public Roads and Waterways shall be followed.

The Documents to be followed in contracting as well as the order of prevalence of the same are determined in the General Conditions for the Contract or in the Contract Agreement.

1:3 D e f i n i t i o n s

A Special Permit is granted by the Resident Engineer after having negotiated, if necessary, with his superiors or experts.

Approvable materials, working methods etc. are those accepted by the National Board of Public Roads and Waterways.

A revision of Bridge Plan may be effected only if permitted or requested by the National Board of Public Roads and Waterways.

An inspecting authority or an inspector of construction works in technical matters related to bridges is generally considered to be the National Board of Public Roads and Waterways or a Division, a separate Bureau, the District

Bureau or an appointed person ordered to carry out the task by the Board. In applying these Specifications to Building Construction Works however, regulations for inspections current in the region concerned shall be followed.

The Resident Engineer is a person appointed by the National Board of Public Roads and Waterways as Chief of Construction Work carried out by the Board or as the Supervisor of the Contract.

The responsible foreman shall carry the responsibility of the Constructor for the performace of work. He shall be adequately qualified in works to be supervised. More detailed regulations for the tasks and qualifications of foremen in concreting works are given in Item 4:1 hereinafter.

1:4 General Quality Requirements

In order to achieve a final result of high quality proper working methods, construction materials and skilled labour shall be employed in construction work.

The final structure shall have the dimensions and functional qualities set out on the Bridge Plan. Deviations from theoretical dimensions shall not be so large that they will be detrimental to the use of the bridge or that they will impair the appearance of the bridge.

A final result of work with the principal dimensions, both vertically and horizontally, not deviating by more than ± 2 cm from theoretical dimensions can generally be con-

sidered satisfactory provided that there are no detrimental bends or curves in structures. The requirements for the evenness of the surfacing of the bridge are the same as those of the road unless otherwise provided on the Bridge Plan.

In installing bearings and expansion joints as well as in other works calling for special accuracy the tolerance is determined more strictly on the basis of the function of the structure. Stricter tolerance standards are also applied for prefabricated structures including steel superstructures of bridges. In these and in their substructures the tolerance is generally not more than ± 1 cm from the theoretical bearing line.

More detailed accuracy requirements concerning structures or parts thereof are also given hereinafter in connection with different stages of construction.

Should no requirements have been given herein or on the Bridge Plan the Constructor shall consider the accuracy of each stage of work in order to achieve the requirements specified for the final result.

The site and any auxiliary areas used shall be tidied up. Scaffolds and other auxiliary structures shall be stripped even from below the ground surface if detrimental from the point of view of the use of the water system, dredging of the route, construction of other foreseeable structures, farming or other causes. (Cf. General Specifications for Road Construction "Common Works").

2: MEASUREMENTS

2:1 General

Equipment used in measuring work shall be inspected. The person carrying out measurings shall be sufficiently familiar with the principles of geodesy and know the accuracy of equipment at his disposal. A report shall be made of measurements indicating the basic measuring points and their relation to the setting-out of the road, the method and equipment and the final location of structures in the selected system of coordinates. Observation series and computations for the principal measurements shall be submitted to the Resident Engineer.

In measuring at least of prefabricated structures and particularly of large steel superstructures account shall be taken of the fact that in the Plans dimensions are given at a temperature of $\pm$ 0°C (theoretical installation temperature).

Directions given in Section "Common Works" of the General Specifications for Road Construction shall be followed, when applicable.

2:2 Basic Measuring Points

The basic measuring points and necessary dimensions for setting out structures are given on the Plan. If necessary new basic points shall be computed and established for the

construction of a bridge in such manner that there will be a sufficient number of such points visible during and even after the work. The auxiliary points shall be permanent and within the required range of accuracy. In general two bench marks are given on the Plan both of which shall be used. If one of the bench marks is far from the bridge site a reliable auxiliary point may be established closer so that the measuring distance will have no effect on discrepancy. Levelings shall not be closed to the bench mark they have been started.

In measuring auxiliary basic points a larger accuracy than that specified for the determination of the dimensions of the structure shall be used. These measurements shall always be closed and leveled out according to the principles of geodesy.

2:3 M e t h o d s a n d A c c u r a c y

The method and equipment shall be selected in view of required accuracy. For example, in measuring the location and principal dimensions of a bridge account shall be taken of the sag of the measuring tape as well as of temperature and typical correction factors.

In principle the accuracy shall be determined as set out in the requirements for finished structures in the Specifications. The accuracy shall however be considerably larger than the required accuracy of measurements owing to any accumulation of errors in measuring. Furthermore, deviations

from theoretical dimensions are caused by deformations in scaffoldings and formwork, hard to assess, by shrinkage and creep of concrete and by deformations resulting from welding stresses.

In normal concrete bridges the accuracy of ± 1 cm in longitudinal measurements and of ± 0.5 cm in vertical measurements should be achieved.

2:4 Checking of Measurements

All the most important measurements, i.e. the determination of the location of bridge foundations, shall be checked either from other basic points or by using another measuring method. If this is not possible several measurings shall be carried out. There shall always be several observations. In the most accurate cases the number of measurements shall be as provided by the principles and general practice of geodesy.

3: FOUNDATIONS AND EARTHWORKS

3:1 General

Foundations shall be constructed and earthworks carried out as set out on the Bridge Plan. Among other things, the foundation pit shall not be excavated too deep since founding on refill is forbidden unless otherwise provided on the Plans. Regulating and filter courses mentioned later herein are not however regarded as backfill materials. In view of difficult excavation, supporting and draining of foundation pits a detailed plan shall be prepared and submitted to the Resident Engineer prior to the commencement of such works.

3:2 Checking Soil Survey Results

The validity of soil survey data on which the Plan is based shall be checked during the work. It should be ensured as early as possible that the quality and the bearing capacity of the ground at foundation level correspond to that assumed on the Plan. Variations in rock surfaces at foundations should also be clarified with the largest possible accuracy so that any deviations are known in good time and that checking or revising the Plan will not result in any suspensions in the work.

Observed discrepancies shall be informed forthwith to the Resident Engineer who shall decide whether more detailed surveys are to be made and whether checking or revising the

Plan is justified.

The performer of piling shall check ground survey data by such a method and with such an accuracy that piles may be acquired or prepared in true dimensions.

3:3 Foundation Pits

3:31 Supporting

Foundation pits shall be excavated with no damage to nearby structures. For supporting walls strained by earth pressure resulting from traffic, permanent buildings or from other structures, static computations shall be made and structural drawings shall be prepared and submitted to the Resident Engineer. Unless otherwise provided, payloads set out in valid loading regulations shall be used in planning.

Temporary supports shall be removed for the part detrimental in some respect. If required, drawings shall be prepared for archives of auxiliary structures to be left underground or in water.

3:32 Excavating and Trimming in the Dry

In foundations on slabs on the ground, excavation operations shall be arranged so that there will be no softening of soil on and below the foundation level. In softening soil, excavating by machine shall be finished about 10...20 cm above the foundation level depending on the type of excavating

machine.

Prior to casting foundation slabs the floor of the pit shall be thoroughly levelled. Extruding rocks and if necessary, larger stones shall be excavated at least 30 cm below the foundation level. Resulting cavities shall be filled with compacted coarse gravel or chippings. Unless otherwise provided on the Plan the ground underneath the foundation slab shall be graded horizontal. Owing to variations in foundation conditions a foundation slab on the ground shall not be stepped unless the matter is considered a revision of the Plan.

If the soil contains silt, fine sand or other slurrying fractions, a gravel or chip layer about 15 cm thick shall be spread and carefully compacted on the bottom of the pit. Alternatively, a 10 cm thick auxiliary slab may be used, if necessary, above a thin gravel or sand layer. If the bottom of the pit is dry and there is no risk of slurrying before casting, these measures may be omitted.

In foundations below the groundwater level drainage may frequently be arranged from an open pit by pumping, for example when the soil is stable and impervious. Sumps should be placed outside the foundation slab and water should be conveyed into them through drains outside the foundations.

In order to improve the stability of the slopes of the foundation pit and to reduce the pressure of water rising from the bottom of the trench the pit shall, if necessary, be

surrounded by sheet piling. When the soil is fine sand or sand, excavation operations below the groundwater level shall always be carried out inside sheet piling.

Should the soil become slurried or should the casting of foundation slabs be obstructed owing to flow of water into the foundation pit, a filter course to convey water into sumps shall be laid on the bottom of the pit. The composition of the filter course depends, among other things, on the grain size distribution of the soil and on the quantity of water. The composition of the filter course shall be determined separately for each case. Should the soil contain fine sand or finer materials and should the flow of water be large, the following type of filter course (from the top) may be used:

- 15 - 20 cm pebbles or chips, dia about 40...65 mm
- 10 cm gravel
- $\geq$ 5 cm sand

As for gradation account shall be taken of consolidation.

When soil layers are cohesionless and highly or moderately pervious the groundwater level should preferably be lowered by pumping from pipe wells placed around the foundation pit. This method calls for the clarification of permeability by means of ground surveys, for a plan prepared by an expert and for special equipment.

Unless otherwise provided on the Plan fill layers on the ground shall be compacted to 95 % of the improved Proctor

density (average), that is, a density of not less than 95 % shall be achieved. This also applies for foundations on backfill material as set out on the Plan.

3:33 Excavating Under Water

If there is the risk of hydraulic failure owing to the flow of water, the foundation pit shall be excavated under water. This can be anticipated if water pumped from the foundation pit carries finer materials and starts to soften the soil calling for discontinuation of pumping forthwith. The risk of hydraulic failure should however be clarified in advance. During excavation operations the surface of water in the foundation pit shall be kept not less than 20 cm above the surrounding water level. Excavating under water may be necessitated also by the large depth of water, large flows and difficulties in constructing sheet piling.

Directions given above shall, when applicable, be followed in trimming the bottom. If necessary, chippings or coarse gravel shall be used as a regulating course.

Should it be indicated by thorough studies and calculations that after constructing the filter course a sufficient protection against hydraulic failure has been achieved, the foundation pit may be drained and the slab cast in the dry. Generally, the foundation slab has to be cast under water.

3:34 Foundations on Rock

The bases for foundation slabs on rock shall be excavated even and horizontal and sloping surfaces shall be stepped. Rock surfaces underneath foundations shall be thoroughly cleaned. Unless otherwise provided on the Plan, foundation slabs shall ha cast directly onto rock.

Anchor steel bars shown on Drawings may be secured in the rock either before or after casting of the foundation slab. The diametre of the slot made for the anchor bar shall be not less than 1.5 times the diametre of the steel bar. Directions on grouting anchor steels are given in Item 4:49 of Concreting Works.

3:35 Protecting Soil Against Freezing

No permanent structures shall be founded on frozen ground. Effective measures shall be taken during construction to prevent the ground from freezing. It shall be noted that the foundations of bridges have been taken down to the frost limit or a little below the same and consequently, the foundation pits shall for the winter be filled to the final height unless heat insulation is used or unless other measures are taken to keep the ground unfrozen.

3:36 Special Directions Concerning Pile Foundations

Proper measures shall be taken to stabilize weak soil in order to prevent damages to foundation slabs owing to

settlement during setting process. In general, a rather thick gravel layer with an underlying timber grillage shall possibly be used for this purpose.

Should stabilizing measures be considered insufficient, a concrete or reinforced concrete slab shall be cast on pile heads to carry strains resulting from casting of the foundation slab. A formwork supported against piles may also be used for this.

3:37 Sheet Piling

Unless otherwise provided on the Plan permanent sheet piling shown on Drawings shall be made of 3" planks driven to a depth not less than 1.5 m below the underside of the foundation slab unless the firm bottom is reached higher up. Sheet piling shall be fixed into foundations at the horizontal bracing by means of bolts, k/k 100 cm, dia 1".

When sheet piling is used to support foundation pits and to form a mould for the foundation slab, they may generally be left on place. Planks shall be cut off flush with the slab surface, unless otherwise provided, i.e. in the permit conditions of the Water Court. In foundations on soil, timber sheet piling shall not be removed from below the foundation slab.

3:4 P i l i n g

3:41 Piles

General quality requirements for piles have been given in Standard Specifications for Foundation Works. Reinforced concrete piles shall be made in accordance with approved Drawings by following regulations for manufacturing prefabricated concrete structures. The permissible tolerance in the lateral dimensions or the diametre of the cross section is ± 5 % provided however that the cross-sectional area shall not be more than 5 % smaller than the theoretical cross-sectional area. The heads of piles shall within the permissible tolerance be straight and at right angles to the longitudinal axle. Accuracy requirements stipulated in Item "Concreting Works" shall be followed when reinforcing bars are placed. The distance of bars from the head of the pile shall be not less than 4 cm. Reinforcing bars shall in no case touch the steel shoe at the pile tip, steel parts of splices or bond steels fixed into the same.

Damaged piles shall be rejected. For example, reinforced concrete piles with exposed reinforcement are regarded as damaged.

During hauling, moving and erecting reinforced concrete piles shall be supported at spots shown on the Pile Drawing. Sudden movements and thrusts shall be particularly avoided (Cf. Item 4:93). It shall be ensured before driving that concrete used in piles has attained the design strength.

In permanent structures, parts of timber piles above water shall be treated with an approved preservative using an approved method.

Regulations for steel piles are given separately for each case.

3:42 Pile Shoes and Splices

Pile shoes and splices shall be of an approved type indicated on the Plan. Splicing, unless provided on the Plan, and changing the pile shoe on the basis of checking of soil surveys will be regarded as a revision of Plan. It shall be noted that the parts of a rigid splice as well as pile shoes shall be fixed into reinforced concrete piles during pouring and consequently, any changes shall be clarified prior to manufacturing of piles. The use of so-called socket splices calls for reducing the permissible pile load.

Unless otherwise provided on the Plan piles shall be made unjointed to design lengths prescribed in Standard Specifications. Jointed piles less than 4 m in length shall not be used.

A separate plan shall be prepared for extending piles from the head by means of a reinforced concrete column.

3:43 Piling Equipment and Device

The pile driver shall be of such a type that piles may be

driven undamaged down to the required depth and raking. When a free-fall hammer is used, the weight of the hammer shall conform with Standard Specifications. The weight of the hammer shall be adjustable, when necessary. The blow on the pile head shall be concentric and the height of fall shall be adjustable within a range of 10 cm and of 5 cm when rock shoes are used.

In order to protect the pile head against damages an effective helmet shall be used. Directions given hereinafter on the penetrations and heights of fall of reinforced concrete piles require that the damping-out and deformation properties of the helmet correspond to three layers of sawn pine core timber of 1" and that during the last few blows a helmet exposed earlier to at least 300 blows shall be used. In driving reinforced concrete piles the auxiliary pile shall be made of steel and have an area of not less than 1/4 of the cross-sectional area of the pile.

The direction of the pile shall be adjustable as required on the Plan. Account being taken of the quality of soil, such a piling rig shall be used as will make it possible to drive the pile to correct direction and location within the tolerances given hereinafter.

Pile driving machines driven with diesel-power, steam or compressed air can be used only with a separate permission. In order to apply for such a permit, technical data of the machine and proper piling instructions shall be submitted. In driving end-bearing piles use shall be made only of

equipment with a heavy piston and driving shall be adjustable and controllable when the pile approaches the firm bottom. If necessary, reference pilings by monkey equipment shall be made to check the driving instructions.

3:44 Driving

Records shall be kept of driving operations according to an approved formula or separate directions. Data mentioned in the Standard Specifications for Foundation Works shall be recorded. The final location and raking ascertained by check measurements shall be indicated in the Pile Map attached to the Piling Records.

Driving shall be started using small heights of fall and as far as there is no significant point resistance in reinforced concrete piles the height shall be kept small in order to protect the pile against damages resulting from tensile stresses caused by shock waves. The situation is particularly dangerous when the point, after having penetrated harder courses (i.e. embankment fill) resulting as a significant skin friction, reaches soft soil layers.

In driving reinforced concrete piles a height of fall of more than 1.0 m shall not be used while the height of fall in driving timber piles shall not exceed 1.5 m providing that the hammer is suspended on a single wire rope. In case of entirely free fall the heights of fall shall be multiplied by 0.8 and by 1.6 when the hammer is suspended on a double rope. If a hammer weighing more than 3 tons is used

in driving reinforced concrete piles or a hammer weighing more than 1 ton in driving timber piles, the maximum heights of fall given above shall be reduced in proportion to the weight of the hammer.

When the pile tip approaches the firm bottom, the heights of fall shall be reduced gradually so that the penetration per blow being less than three times the largest permissible final penetration, the values given in the Table below shall be used. Driving a point-bearing pile may be ended when the point has reached the firm bottom set out on the Plan and when the final penetration per blow (= e), determined on the basis of the last 10-blow series, is lower than the maximum values of the Table. Moreover, the penetration during the last three 10-blow series shall show a continuous decrease. The height of driving depending on the length of the pile shall confirm as closely as possible to the value given in the Table.

Pile	Largest permissible e (mm) when weight of hammer is				Corresponding height of fall (h) (cm) when the length of pile is			
	1.0Mp	2.0Mp	3.0Mp	4.0Mp	5 m	10 m	15 m	20 m
Reinforced concrete pile 25x25 or dia ø 28 cm		0.7	1.5	2.2	30	35	45	50
Reinforced concrete pile 30x30 cm			1.0	1.3	35	45	55	60 [1]
Timber pile top dia 7"	2.0	4.0	5.0		70 40 35	85 50 40	100 60 45	115 70 50

15.12.1970

Notes:

1) The weight of hammer shall be not less than 4.5 Mp.

It is provided in the Table that

- a helmet with a damping-out coefficient = 2/3 mentioned in Item 3:43 is used in reinforced concrete piles
- hammer is suspended on a single wire rope
- there are no splices in the pile
- no auxiliary pile is used
- the pile has not reached rock or a large stone
- at least in general, an end-bearing pile is concerned
- the relation of the weight of hammer to the combined weight of pile, auxiliary pile and helmet is $>$ 1 in concrete piles and $>$ 2 in timber piles.

For a freely falling hammer, the value of the height of fall shall be multiplied by 0.8 and for a hammer suspended on a double wire rope by 1.6. In driving spliced piles or when an auxiliary pile is used, the length of the pile shall be taken as the combined length and furthermore, the height of fall shall be increased as considered necessary separately for each case, but not by more than 50 %. It is not necessary to interpolate the intermediate values. Should the length of the pile exceed 25 m, driving instructions shall be determined separately for each case. This applies also for cases in which the conditions concerning the use of the Table cannot be satisfied. Should the directions cause trouble during the work they shall be revised.

Should the pile suddenly meet rock or a large stone, driving

shall forthwith be ended. If the pile is furnished with a rock shoe driving shall be continued according to directions given hereinafter. If the pile is equipped with a normal pile shoe checks may be made by using heights of fall not larger than half the values of the Table to find out whether the pile slips on the surface of rock or stone and whether the pile is not damaged. Considering soil survey results and other relevant factors, it shall be decided separately for each case whether the pile should be replaced and whether the new pile should have a rock shoe.

When the pile reaches rock as assumed on the Plan, the height of fall shall not exceed 20 cm. If the pile has a hardened rock shoe, driving shall be continued as follows:

- 100 blows with height of fall of 10 cm
- 100 - " - 20 cm
- 100 - " - 30 cm

If it is observed that the pile tip has penetrated by these 300 blows not less than 20 mm in rock, the supporting niche is sufficient. Otherwise, driving shall be continued with a height of fall of 30 cm until the required penetration has been reached. For the purpose of checking, at least three (3) ten-blow series shall then be driven with a height of fall of 40 cm. The penetration shall not exceed 2 mm during a 10-blow series. If the pile is observed to slip on the rock surface, driving shall be re-commenced with a height of fall of 10 cm. The above directions imply that a 3Mp hammer suspended on a single wire rope is used and

that the strength category of concrete is at least K 400.

Separate directions are given for each case on driving friction and cohesion piles as well as steel piles.

3:45 Post-Driving

The height of the pile head shall be leveled immediately after driving. When all piles of a group have been driven, a new leveling shall be carried out. Should piles have heaved, post-driving is necessary.

3:46 Special Piles

Special piles include, among others, cast-in-place reinforced concrete piles (large diametre piles), for which holes are made either by excavating or by driving. As for dimensions and reinforcement, these piles shall conform to the Bridge Plan and meet the accuracy requirements given in Item 3:47 as to location and direction.

Unless otherwise provided on the Bridge Plan so-called bored piles shall be driven down to rock. Regulations for underwater casting shall be followed in concreting. Should water enter the pouring tube the pile shall not be approved.

Should the quality of rock under a bored pile be poor or should the pile be left on moraine, two steel tubes, internal diametre 2", extended with tightened socket joints shall be left in each pile. After hardening of concrete checks shall be made through the tubes for the firm bottom

below the pile. Moreover, the soil or the rock shall be grouted with cement mortar.

The tubes of Franki piles or reinforced concrete piles cast-in-place by a similar method shall primarily be driven down to the firm bottom determined on the basis of soil surveys unless otherwise provided on the Plan. Only until the ground moraine or a corresponding coarse soil has been reached the bearing capacity of the pile may be assessed by so-called piling formulas. If water enters the casing tube during pouring of Franki piles, the pile shall be rejected.

As for special piles directions for each method shall be followed and submitted in complete form to the Resident Engineer prior to the commencement of work.

3:47 Accuracy Requirements

Unless otherwise required by the Plan, the location of the pile head on the cut-off level shall not deviate more than 30 cm from the location indicated on the Piling Map. The axle of the centre of gravity of a group of parallel piles on the cut-off level shall not deviate more than 10 cm in the longitudinal direction of the bridge and 15 cm in the transverse direction from the theoretical location. The raking of an individual pile shall not deviate by more than 2 cm from that given on the Plan when measured over a length of 100 cm.

Should the deviations be larger than specified above the static computations of piles shall be revised. If necessary,

the pile group shall be strengthened by additional piles conforming to the revised Bridge Plan.

3:48 Driving Sequence

In a group of parallel piles the innermost piles should generally be driven first and driving should then be continued gradually towards outer piles in order to eliminate the penetration of subsequent piles owing to the compaction of soil by piles driven earlier. Difficulties may be encountered particularly in thick fine sand courses. If necessary, the Plan shall be changed and for example, the group of piles may be split into a fan-like form in which case the distances between pile tips will increase.

Should there be an embankment pile foundation behind the abutment, the pile foundation shall be constructed before piling the abutment, which shall generally be started from the back edge of the base slab towards the bridge opening, if this sequence is possible from the point of view of the movement of the piling rig.

3:49 Other Directions

If the piling rig has to be taken onto a platform the latter shall be of sturdy construction so that the movement of the platform will not result in any displacement, deflection or damage of piles during driving. A special permit is required for driving or excavating from a floating pontoon platform.

In order to improve penetration, water jetting shall be used if necessary, and a detailed plan of this method shall be submitted to the Resident Engineer prior to the commencement of work.

It may separately be provided on the Bridge Plan that reinforced concrete piles shall be equipped with an inspection tube. The tube, having an internal diametre of not less than 32 mm shall be attached into the pile concentrically. At joints, the deviation from the concentric position shall not exceed 1 mm. The tube shall be jointed with sockets.

As for spliced piles or auxiliary piles, the joints shall be tightened during driving in order to prevent soil from entering the inspection tube.

Checks shall be made after driving to ensure that the tube is open and straight down to the tip of the pile.

3:5 Earth Filling

3:51 Refilling Foundation Pits

Unless otherwise provided on the Bridge Plan foundation pits shall be filled up to the level of the ground surface or to the level of the road cutting or of dredging of the river bed.

Refilling shall be carried out with care using materials not causing damage to concrete surfaces and any damp-proofing and that the subsequent compaction of the fill will not

be detrimental. In cases when the foundation pit will lie even partly below a road, railroad or street, the fill shall be compacted in layers. The required density is 95 %. Underwater fill materials shall be coarse gravel rich in stones or crushed rock.

Behind the front wall of the abutment or the wall of the frame the fill material shall be frost-resistant to a distance of not less than 2 m from the surface of the structure facing the ground, measured to the direction most disadvantageous for the penetration of frost. (Cf. Item 1540 "Embankments of Special Structures and Backfilling Behind Bridges" of the General Specifications for Road Construction).

Unless an actual protective layer against erosion is provided on the Plan, such coarse fill material shall be used under water as will not be carried away by any currents.

In backfilling and compacting foundation pits, one-sided earth pressures not provided on the Plan or possibly causing extra strains or even displacement of the structure shall be avoided (Cf. Directions on backfilling behind frame bridges).

3:52 Backfilling Behind Bridges

Backfilling behind bridges shall be carried out in conformance with directions and instructions given in Item 1540 of the General Specifications for Road Construction.

In backfilling behind frame bridges the difference in height

of fill behind the walls shall not exceed 0.5 m unless otherwise provided on the Plan. In the transverse direction the fill layers should be made horizontal.

Should the superstructure be supported, on one or both ends, on moving bearings, the back of an abutment founded on piles shall be backfilled up to normal embankment height before the superstructure is concreted or placed in final location. However, other or deviating regulations for backfilling behind bridges may be given in the Bridge Plan.

3:6 Facing of Slopes

The method of facing is determined on the Bridge Plan. Facings shall conform to Item 1750 of the General Specifications for Road Construction. Grassing of bridge slopes shall be made by the method prescribed for the adjacent road slope.

It shall be noted that the width of facing on the top determined in the Bridge Plan is at least 1.0 m and that the borderline between the slopes of the bridge and the road shall be sloping backwards (from the bridge) (Cf. Drawing No. DK/16-10). If there will be a gutter in the slope, the borderline of facings shall coincide with this gutter, however.

3:7 Sewerage Behind Bridges

3:71 Sewers and Subdrains

Proper steps shall be taken to prevent water coming from the road embankment or from the bearing bank to the fill behind the bridge from collecting behind concrete structures and from forming one-sided water pressure.

In most cases the use of pervious fill material behind the bridge and/or in the foundation pit at proper location is sufficient. If necessary, sewer or subdrain pipes shall be used and holes shall be reserved in concrete structures.

3:72 Surface Waters

The gutter indicated on the Bridge Plan shall be constructed to convey water collecting at the end of the bridge down along the slope so that no damage is caused to the facing of the bridge and the slope.

Unless other dimensions are given on the Plan the gutter shall be made of prefabricated concrete sections, $d \geq 20$ cm. Alternatively, the gutter may be constructed of stone. If there is a stone facing in the bridge slope, the gutter shall also be made of stone material. The direction of the gutter shall be parallel to the gradient of the slope.

The spots on the slope exposed to water from outlets of the bridge deck shall be strengthened with a stone or chip layer not less than 70 cm in thickness and a gutter shall

be made to convey waters away as described above. The size and form of the area to be protected shall be considered separately for each case. It is preferable most frequently to place the gutter at the border of the facing of the underside and the slope of the bridge. The gutters shall be embedded on a well compacted layer of coarse gravel or chippings at least 50 cm in thickness.

4: CONCRETE STRUCTURES

4:1 G e n e r a l

This Section of the Specifications deals with cast-in-place concrete, reinforced concrete and prestressed as well as prefabricated concrete structures.

Primarily, the current decision of the State Council on regulations for concrete and reinforced concrete structures as well as the decision of the Ministry of Communications and Public Works on the application of the same and comparable Standard Specifications for Prefabricated Concrete Structures shall be followed in the work.

The Standard Specifications for Prestressed Concrete Structures and other instructions issued by RIY, RIL or VTT shall be followed, when applicable.

The Chief of Concrete Works is either the Resident Engineer, the foreman of concrete works appointed for the job or so-called Chief of difficult construction works. The Chief of Concrete Works shall be responsible for the planning and performance of all concreting operations; scaffolding, formwork, reinforcement, concreting, stripping of formwork and scaffold and for any prestressing and grouting operations etc.

Structural and working plans determined hereinafter shall be prepared and submitted to the Resident Engineer for approval in good time before the start of works. No devia-

tions shall be made from an approved plan without a permit of the Resident Engineer.

The commencement of each separate pouring operation shall be informed in good time for the arrangement of checking and supervision. Pouring shall not be started without a permit of the Resident Engineer.

4:2 S c a f f o l d i n g a n d F o r m w o r k

4:21 Plan

A plan shall be drawn up of scaffolding and of larger formwork structures. The plan shall consist of drawings and static calculations.

Among other things, the calculations shall indicate:

- construction materials and allowable stresses
- loadings
- quality of soil, permissible strain and assumed settlement
- deflections and pre-cambering

The Drawings shall indicate, among other things:

- construction materials
- loadings
- any restrictions as to the rate of pouring
- pouring sequence
- quality of soil and largest stresses
- accurate dimensions
- pre-cambering

- holes for cleaning of moulds and concreting.

4:22 Loadings

In the design of scaffolding, loadings during the work - weight and impacts by hauling equipment, labour etc. - shall be taken into account in addition to the weight of structures.

Unless a more detailed calculation of these additional loads is made the live load shall be assumed as 0.30 Mp/m^2. The unit weight of reinforced concrete shall be assumed as 2.5 t/m^3 in the design of scaffolding and formwork.

Large scaffolding shall also be designed for the wind load set out in loading regulations as well as for the pressure of ice and water. Sideway thrusts resulting from concreting shall be taken into account in the design although they were not calculated in more detail.

Pouring pressure against formwork shall be determined in accordance with formulas in general use. The rate of pour and the time of setting assumed in calculations shall conform to the rate of pour and concrete mixture used in the work. If necessary, the time of setting shall be determined by testing.

4:23 Deformations and Pre-Cambering

Should the deflection of beams carrying the formwork exceed 5 mm a pre-cambering corresponding at the largest possible

accuracy to the assumed deflection shall be arranged. Any settlements of soil or end-bearing piles as well as deformations at the joints of timber structures shall also be assessed and considered as pre-cambering.

The pre-cambering of scaffolding is further affected by deflections resulting from dead load in the structure as well as by any other deformations indicated on the Bridge Plan.

4:24 Bracing of Formwork

Formwork sheeting shall be braced and tied with care. Tie-rods, spacers and props shall be designed in such manner that they will not cause any detriments from the point of view of the strength or the appearance of the structure. Tie-rods on visible concrete surfaces shall be removed or cut off at a depth of not less than 3 cm. No holes shall be made by tie-rods at locations in which surface waters may stain exposed concrete surfaces. In structures exposed to water pressure tie-rods shall be of approved type (i.e. bolt with welded flange 5x100x100). Wooden or cardboard spacers and props shall not be left in concrete without a separate permission.

Tubes or similar moulds for hollows shall be tied into beams carrying the moulds or into the joists. The design of ties is determined by the uplift resulting from concrete mixture.

4:25 Formwork Sheeting

In surfaces exposed to view the lining boards in columns and in similar sections shall be placed vertically and in abutments or superstructures horizontally unless otherwise provided on the Bridge Plan. In curved superstructures boards shall in general follow the form of the bridge.

In exposed surfaces, clean board planed from three sides (dimensioned) shall be used and the rough face shall be placed against concrete. Joints shall be placed at the joists. The use of tongued and grooved boards shall be prescribed separately for each case. Lining sheets may be used only with a separate permission. In other surfaces, good board of uniform thickness or similar sheet material shall be used.

Extruding corners shall be chamfered 2x2 cm unless otherwise provided on the Bridge Plan.

The expansion of timber when sprinkled with water shall be taken into account in preparing formwork.

4:26 Openings for Pouring

The formwork shall be provided with a sufficient amount of openings to be closed during the work, through which concrete may be poured into the moulds and compacted. The number of such openings depends, among other things, on the dimensions of the structure, on the spacing of reinforcement, on the requirements specified for density of concrete

and on available machinery and it shall be considered separately for each case.

If possible, these openings shall be placed on the sides facing the ground. Closing of holes shall be effected in such manner that there will be no defects, at least in visible surfaces and consequently, parts temporarily removed from the original formwork should be used for closing.

4:27 Trimming Before Pouring

Prior to the start of pouring the moulds shall be thoroughly sprinkled. Boards shall be made wet deeply. This generally means that the formwork shall be kept wet at least for one day. The surface of the moulds may become dry just before pouring.

A separate permit is required for the use of shutter oils.

Prior to pouring, all waste, ice and snow as well as ponded water shall be removed. If necessary, holes shall be left for this purpose in the formwork.

4:28 Pouring Sequence

In planning of scaffolding allowance shall be made for the pouring sequence prescribed on the Bridge Plan. Unless a pouring sequence has been given in the Bridge Plan, it shall be determined in connection with design of scaffolding.

The general principle in planning the pouring sequence shall be that no damage shall be incurred to concrete in setting process by deformations of the scaffolding. The shrinkage of concrete and pouring capacity are also factors affecting the pouring sequence and the spacing of construction joints.

4:29 Other Directions

Scaffolding may be founded on frozen ground only in the case that there will be not enough time for melting before concrete has reached the strength calling for stripping of scaffolding. Effective measures shall always be taken to ensure that melting, flow of surface waters, pressure of water and ice etc. will not soften or scour soil underneath scaffoldings or cause other damage to them.

No detrimental impacts shall be caused to the structure by stripping of scaffolding. The scaffolding of arched and if necessary, of beam bridges shall be provided with adjustable hoisting device by which the scaffolding may be lowered as complete sections by 2...3 cm.

As to load-carrying capacity, deformations and adjusting device, the structure of special scaffolding equipment shall be of reliable type. Careful checks shall be made during erection that parts destroyed by corrosion or wear or otherwise damaged are replaced by good ones. Directions for erecting given by the manufacturer shall be followed.

In steel scaffolding, joints based on friction shall not be used in other than transverse and diagonal bracing stiffening the structure unless these joints have been made as set out in Item 5:34 hereinafter. Tie joints used in bracings shall be of approved type. Care shall be taken in installing tie joints to ensure that there will be an effective pressure at the joint.

Scaffoldings for prestressed structures shall allow for free movement during prestressing. Horizontal and diagonal bracings may be removed as required after hardening of concrete. The load-carrying capacity of scaffoldings shall not however be endangered. When flexible supports are used care shall be taken to ensure that the structure will not be supported by scaffolding after full prestressing has been achieved.

Shutters for inside surfaces of box beams shall generally be stripped, which shall be taken into account in the design of shutters and in planning of works. The formwork may be left in place only with a separate permission.

The material used for shuttering hollows shall be resistant to stresses by weather and pouring of concrete including moisture.

Prior to the start of concreting, scaffoldings and formwork shall be inspected and approved. It shall be ascertained in the inspection that scaffoldings and formwork conform to the Drawings of both permanent structures and

of scaffoldings and formwork. Unless stricter requirements have been specified owing to other reasons, the absolute deviation from theoretical dimensions shall be not more than 1.5 cm both in horizontal and in vertical direction. There shall however be no lower dimensions than specified in load-carrying structures with a thickness d $\leq$ 100 cm.

4:3 Reinforcement

4:31 Adequacy of Material

In case that reinforcement bars are delivered to the site in closed bundles with markings set out on Standard Specifications and if the certificates of tests for corresponding manufacturing stocks based on tests made by the manufacturer indicate that the material conforms to the requirements, the adequacy of steel material can be considered verified. The same may apply for opened bundles if it may undisputedly be ascertained to which stocks bars belong and if corresponding certificates of tests are adequate.

Unless the adequacy of reinforcing bars can be ascertained in the way described above, tests set out on Standard Specifications shall be made of bars delivered to the site. Directions for test sampling are given by the Resident Engineer. Tests shall be made at an officially approved material testing institute.

Steel bars and wires for prestressing cables shall always be delivered to the site so that bundles and coils are

marked with symbols indicating the manufacturing stock and other data needed for ascertaining the adequacy of material. The orders of shipment and certificates procured by the manufacturer to be delivered to the Resident Engineer shall fully correspond to the shipment brought to the site. Adequacy tests set out on Standard Specifications shall always be made of prestressing cables at an officially approved material testing institute. Tests made by the manufacturer are considered quality control tests. More detailed directions for test samples are given by the Resident Engineer. In connection with the tensile test the stress-strain curve of steel, to be used as the basis for prestressing plan, shall also be determined.

Records shall be kept of steel material brought to the site. Those records, preferably kept in the form of a table, shall indicate the following data:

- quantities of delivered steel; diametres, qualities, stock (charge) numbers, number and weight of bundles or coils
- certificates of tests (Nos. and dates) of the manufacturer or of an officially approved testing institute
- numbers of test specimens taken on the site
- remarks, provided that requirements for material tests or other data needed for ascertaining the adequacy have not been satisfied.

All shipment orders, material testing reports, lists of test specimens and other documents as well as the markers of steel bundles shall be delivered to the Resident Engineer, who shall check that these documents conform to the

records and that no steel, the adequacy of which has not been ascertained, has been used on the site. The quantities of steel delivered to the site and used in structures shall be compared.

4:32 Placing Reinforcement in Formwork

Reinforcing bars shall be placed in formwork to correct positions and tied so that they will not be displaced during pouring.

The concrete spacers of reinforcement shall be made of high-class concrete and shaped and placed so that the surface against shuttering is as small as possible. At the pouring stage tie wires shall be fixed into spacers to connect them firmly with reinforcing bars. Spacers made of materials other than concrete may be used only with a separate permission. In casting direct onto ground clean stones may however be used to prop the reinforcement. Unless otherwise required by the weight of reinforcement or other causes at least two spacers per square metre shall be used.

Reinforcing bars shall be tightly fixed. Tie wires shall be bent so that they will not stick to moulds. If necessary, additional steel bars shall be used.

According to the Standard Specifications for Concrete welding of reinforcing bars is restricted. Fixing stirrups by means of arc or autogeneous welding may be considered with a special permission only when both the stirrup and the bar

are made of steel of quality A 22 S. Welding deformed steel bars part of functioning reinforcement by the above methods is absolutely forbidden although the steel were of quality A 40 HS. Moreover, prestressing steel and steel mesh reinforcements shall be carefully protected against welding heat and sparks.

In gereral, all steel bars of the structure to be cast shall be tied before pouring. This also applies for dowels. At densely reinforced spots, sufficiently large spacings should be left to allow for proper pouring. Deviations from spacings set out on the Drawings are however possible only if permitted by the Resident Engineer. Larger deviations shall be considered revision of the Bridge Plan.

Detailed drawings shall be prepared of the supports of prestressing cables and they shall be submitted for the approval of the Resident Engineer before cables are installed. During installation and in any case before pouring, checks shall be made to ensure that cable sheathing is undamaged. Any holes shall be repaired, i.e. by insulating tape.

4:33 Accuracy of Installation

In installing reinforcement the maximum deviations from the dimensions set out on the Plan or in the Standard Specifications for Concrete are as follows:

- Thickness of protective concrete (a):

There shall not be dimensions lower than those given as minimum in the Standard Specifications for Concrete or

in Drawings. Theoretical dimensions shall not be exceeded by more than 0.5 cm when the thickness of the structure, $d \leq 20$ cm, 1.0 cm when 20 cm $< d \leq 50$ cm and 2 cm when $d > 50$ cm.

- Free spacing of steel in one row (b);
  $\pm$ 0.3b
- Free spacing of steel rows (h);
  $\pm$ 0.2h
- Longitudinal position of steel in the structure;
  $\pm$ 10 cm. This tolerance is valid unless the longitudinal position of steel is determined by some other of the above dimensions. An excessive length larger than 10 cm is however permitted unless of no detriment, i.e. for concreting.

In installing prestressing cables the maximum permissible deviations are as follows:

- Position in moulds against cable in the vertical direction measured from the sheathing to random direction;
  $\pm$ 0.5 cm unless more accurate installation is required by anchorages or the dimensions of the structure. There shall be no extra bends between supports or dimensioned points.
- Longitudinal position $\pm$ 5 cm unless placing of anchorages is of decisive importance.
- Anchorages shall, within the measuring tolerance, be at right angles to the longitudinal axle of the cable, unless a deviation is expressly permitted in the national approval documents of the prestressing method concerned.

4:34 Other Directions

Storing and handling steel on the site shall be arranged so that removal of rust, grease, ice, concrete and other impurities prescribed in the Standard Specifications will be eliminated to the minimum. Generally steel shall be procured as accurately as possible during the progress of work in order to reduce the time of storage. Prestressing steel should always be stored under cover and protected against corrosion by earth and other materials.

At temperatures below + 5°C impacts and sudden bending shall be avoided in handling reinforcing steel. Bends shall be inspected. At temperatures below -10°C deformed steel bars may be bent only if permitted by the Resident Engineer. The adequacy of steel stock to be used when bent cold shall be ascertained by tests. At temperatures below -20°C bending and other handling of reinforcing steel is strictly forbidden.

4:4 C o n c r e t i n g

4:41 Concreting Plan

Prior to the commencement of actual concreting operations a plan shall be prepared of general arrangements related to concreting. The plan shall be submitted for the approval of the Resident Engineer. The Plan shall indicate:

- supervisory staff, organization and any experts
- delivery of raw materials or concrete mix to the site

- quality requirements of raw materials
- concreting equipment
- hauling of concrete mix
- precautions in view of suspensions
- precautions for concreting in winter
- advance tests
- checking the adequacy and quality of concrete and strengthening process, i.e. a test sample programme.

In course of work the Plan shall, if necessary, be complemented so that prior to pouring of each project a detailed report of the arrangement of works can be submitted to the Resident Engineer.

In addition to the Standard Specifications for Concrete, directions issued by RIL shall be observed, when applicable ("Directions for Concreting", "Directions for Winter Concreting", "Directions for Patching and Repairing", "Explanations of the Standard Specifications for Concrete").

4:42 Preparing Concrete Mix

The deliveries of raw materials shall be arranged so that the quality will be uniform throughout the work or at least during continuous pouring. The grain-size distribution and moisture of aggregate and the elasticity of concrete mix shall be continuously checked. The accuracy of batching devices shall also be ascertained by continuous checks. In order to prevent differences in colour the same type of cement prepared by one manufacturer shall be used in all

structures exposed to view.

In preparing mix on the site a laboratory assistant shall always be present during pouring. When additives are used there shall be a person familiar with batching and mixing of additives and with necessary equipment at the concrete plant.

A permission of the Resident Engineer is required for the use of additives. Unless the use of an additive has been prescribed in the Plan it is possible only with a separate permission. Additives improving the workability and density of concrete are recommended, however, in structures exposed to water pressure as well as in thin and densely reinforced sections. A proper additive may furthermore be advantageous in underwater pouring and when the hauling distance is large.

As a precaution for any suspensions in the preparation of concrete mixture there shall be two independent mixing plants with batching and additional device on the site unless the provision for concrete has been ensured by other means. In some exceptional cases when the quality of structure is not significantly impaired by suspensions, the Resident Engineer may give permission to start pouring operations without the above precautions.

Concrete shall be proportioned by an approved method. All possible special mixes used, for example in starting or ending of pouring or in very densely reinforced sections shall be proportioned in advance. When ready-made concrete

is used, data given by the manufacturing plant on the composition of mix shall be attached to the concreting records.

In case changes shall be made during the work in preparation or haulage of mixture on the basis of changes effected on the pouring site or of observations, a communication line shall be arranged between the mixing plant and the pouring site.

4:43 Hauling and Pouring

Segregation during hauling and handling shall be prevented. If necessary a proper additive shall be used.

Concreting operations shall be arranged in such manner that sections between construction joints set out on the Plan can be poured in continuous operation. Concreting shall be performed systematically in accordance with a clear pouring formula. Pouring shall generally be started from the lowest point of the mould.

In pouring wall-like structures lifts should be made horizontal. In the lowest layer at the bottom of moulds or facing, the construction joint, a mixture richer in cement - the water/cement ratio reduced by 0.15 - and more workable than in other pouring operations shall be used. In the upmost layers on a depth of about 1 m, a stiffer mix in which water has been diminished by about 5-10 % the quantity of cement being as before should be used.

The thickness of a lift shall not in general be more than

30 cm. In pouring thin walls and columns with a small cross-sectional area the thickness of a lift may however be increased up to 50 cm. When tight lining sheets are used the lifts shall not be more than 25 cm in thickness.

The design pressure of moulds shall always be considered when the rate of rise is determined. The use of additives, mainly of a retarder is of decisive importance in this respect. In view of settling and shrinkage after pouring, the rate of rise shall not generally be more than 0,5 m per hour. In sections with a small cross-sectional area, in which the above factors will not have a significant effect, a separate permission may be given for a more rapid rate of rise.

The elasticity and the grain-size distribution of concrete mix shall be determined to suit the dimensions, form and spacing of reinforcement of the structure. In general, the mixture should be so stiff as is possible in view of placing into moulds and of adequate compaction. Elasticity and grain-size distribution shall be chosen on the basis of the average properties of the structure. At densely reinforced and narrow spots, more elastic and fine-grained mix shall be used, if necessary. Care shall particularly be taken to ensure that the backgrounds of the anchorages of prestressing cables will be carefully filled and compacted. In edge beams and other structures exposed to the effect of salts in which a resistant surface is required, the mix shall be as stiff as possible and the segregation of water

shall be reduced to the minimum.

In compaction, poker vibrators of various sizes depending on the dimensions and the spacing of reinforcement of the structure shall be emplyed. Selecting the most advantageous vibrator in view of compacting is also affected by the frequency of vibrations. The smaller the maximum grain size of concrete mixture, the larger shall the frequency of vibration be. If necessary, the matter shall be decided by means of tests on the site.

The operator of the vibrating device shall work systematically in order to make the mix thoroughly compacted, particularly for parts facing the moulds. The poker vibrator shall generally penetrate by about 15 cm into the lift compacted earlier. In structures exposed to water pressure the penetration may be increased so that the lower lift will be thoroughly re-vibrated. In the upmost lift post-vibration shall be performed about half an hour prior to the start of the setting process. In all cases vibrating concrete, in which setting has already started is absolutely forbidden. Contacts of the vibrator and reinforcement shall therefore also be prevented, if possible.

4:44 Concreting in Cold

In concreting plans precautions shall be taken in good time against lowering temperatures. The heating equipment and shelters on the site shall be so effective that even under unfavourable conditions they prove adequate for

heating of raw-materials of concrete, formwork and poured concrete and for the preservation of heat.

The temperature of mix water shall be adjustable. The water pipe leading into the mixer shall be provided with a thermometer. Storing, melting and heating aggregate shall be arranged in view of the smallest possible variations in moisture.

The temperature of concrete mix shall not be unnecessarily raised. Attempts shall be made to ensure that during hauling and handling, the temperature drops as little as possible and that it remains constant after pouring into moulds. Continuous checks shall be made for the temperature of concrete mix at the concrete plant and on the pouring site. In order to check the temperature of poured structures, a sufficient number of thermometers or inspection tubes shall be placed into structures.

Special attention shall be given to heating of rock and concrete at construction joints as well as to conservation of heat. The ground shall also be kept unfrozen (Cf. 3:35).

Poured structures shall be kept continuously heated - temperature above +0°C - until it has been ascertained, by checking the development of strength, that concrete has reached the strength set out as objective on the Concreting Plan.

If there is reason to doubt that concrete has frozen, it shall forthwith be informed to the Resident Engineer. The

quality and the scope of damage shall be forthwith studied and a repair plan be prepared and submitted for the approval of the Resident Engineer. Repairs shall be made as soon as possible in view of the Plan and prevailing conditions.

Electrical heating can be used only with a separate permission. In structures where large shrinkage stresses can be anticipated the use of this method shall be avoided. Electrical heating shall always call for a plan prepared by an expert.

Heating and protecting measures taken shall have no detrimental consequences to the final result. For example, heating equipment shall not be placed so close to structures that damages are caused by overheating to concrete surfaces. No recesses shall be made in cast concrete surfaces by protective covers or their props. Surfaces stained by oil or coke baskets shall be tidied up.

4:45 Concreting Under Water

Concrete shall be proportioned so elastic that it will easily flow through pouring pipes. In general, an additive improving workability and reducing segregation shall be used. The proportioning strength shall be determined in such manner that the reference strength of test specimens made of mix is not less than 1.25 times the design strength. The quantity of cement shall however be not less than 350 kg/m^3. In the beginning of pouring operations until con-

crete has completely covered the bottom, the quantity of cement shall be increased by 50 kg/m^3 compared to normal proportioning.

The rate of rise of concrete shall be not less than 30 cm per hour. When an additive retarding the rate of setting is used, even a slower rate of rise may be used. The diametre of pouring pipes shall generally be not less than 25 cm. The spacing of pipes shall be not more than 5 m or twice the thickness of the slab. The distance from the walls of the formwork shall be half of this. The height of fall of mix, that is, the distance from the head of the pipe to the surface of the concrete shall be not less than 3 m also in the final stages of pouring. Checks shall be made prior to the start of pouring to ensure that there are no leakages in the pouring pipes.

Pouring shall be commenced by using a plug in the pouring pipe preventing water from entering the funnel and pushed out by concrete. During pouring the end of the pipe shall all the time be kept inside the mix by about 0.5 - 1.0 m and in any case so deep that no water may enter the pipe. Pouring should be carried out in one continuous operation. Generally, a suspension in no pipe shall last for longer than half an hour.

Constructing construction joints not set out on the Plan in structures to be concreted under water shall always be regarded as a revision of the Bridge Plan. The surfaces of joints shall generally be indented and all tensile stresses

shall be covered by reinforcement.

Structures to be concreted by the above method - also known in Finland as the "Contractor Method" - shall be cast so much higher that the dimensions set out on Drawings will be filled with sound concrete. Bumps around pouring pipes may be levelled by vibrating as soon as pouring has been completed. The surface of a construction joint on a structure concreted under water shall be removed to a depth in which fully sound concrete is reached. For other parts the excessive thickness of the foundation slab shall be removed only if it is detrimental (Cf. Permit conditions of Water Court). The mould above water may be emptied of water after concrete has attained 50 % of its design strength.

With a separate permission underwater concreting may be performed by "Colcrete", "Prepackt" or other special methods in accordance with approved specifications.

4:46 Construction Joints

Vertical construction joints shall be cast against the formwork. Timber formwork may however be replaced by a steel mesh suitable for the purpose. Even in this case board shall be used next to the mould in order to make the border of the joint regular. The mesh shall not be closer than 3 cm to the surface of concrete. Board about 5 cm in width shall be used also in horizontal construction joints at the edges in order to obtain a straight borderline. If

permitted or required by the Resident Engineer triangular battens may be used in construction joints although not provided on the Plan.

The mould for the joint may be stripped as soon as possible without damaging any set concrete, in general not earlier than two weeks after the completion of pouring provided that concrete is of a normally hardening type. Unless the construction joint ends i.e. at a shrinkage lane, for the pouring of which a certain interval has been prescribed, pouring should be continued as far as possible from the point of view of stripping of moulds and of handling of construction joints.

From a joint surface in which concrete has hardened, cement film shall be removed, i.e. by chiseling or dressing. If this is not possible the joint shall, even prior to pouring of the construction joint, be provided with additional reinforcement and/or grooves. In construction joints of structures exposed to water pressure a metal sheet or a special jointing strip shall be used. Altering the location or structure of construction joints shall be regarded as a revision of the Bridge Plan.

Cement film may be removed from horizontal construction joints also by wire brushing after stiffening of concrete, that is, normally in 8-10 hours after pouring. Loosened material shall be removed by using, for example, water jetting and a smooth brush in such manner that stone particles are cleaned.

In handling construction joints care shall be taken to ensure that the edge of the joint will be undamaged and straight. Prior to continuation of pouring, moulds shall be tightened to prevent concrete mix from penetrating between the mould and concrete poured earlier. Immediately before pouring, joint surfaces shall be thoroughly cleaned and all loose parts shall be removed. After sprinkling the construction joint shall be dried before pouring is started. When pouring is started above a horizontal construction joint the mixture shall normally be richer in cement and more workable than in other pouring (Cf. 4:43). Concrete facing the joint shall be carefully compacted.

Concrete with a retarder may be used in construction joints by a separate permission. Even in this case the joint shall be bordered by the mould so that there will be no thin concrete layers susceptible to drying. Evaporation from the mixture shall be prevented by using, for example, tight plastic membranes. Curing agents to be sprinkled or brushed on concrete surfaces for this purpose shall not be used. Setting of concrete shall be retarded to such extent that when pouring is continued from the joint, concrete mixes of different age may be blended by means of vibrators. Any dried surface layers shall be removed from the joint prior to placing new mix or vibrating old ones. The retarded area shall be of such a length that concrete already set will not be damaged by vibrating of the joint, i.e. should the vibrator touch reinforcement. The length of such an area shall in all cases be not less than 1.5 m.

4:47 Handling and Curing of Concrete Surfaces

Poured surfaces shall be struck off with timber floats unless otherwise provided on the Bridge Plan. A separate finished layer made later is not permitted. Cement and water shall not be used in trimming.

Special attention shall be given to the evenness and the form of concrete surfaces exposed to view. No pockets of water shall be left on concrete underlying the water-proofing layer. At least for parts above the depth of frost penetration the surfaces of foundation slabs shall be made sloping outwards by about 1:50 and so even that no water will collect on the surface.

Surfaces poured recently shall be adequately protected. Drying of concrete surfaces shall particularly be prevented even during the first day. Sprinkling shall not however be started before the surface has set. Evaporation may best be prevented by using tight protective covers. With a separate permission, curing agents sprinkled on the surface before the setting process may be used. The effect of such materials both on concrete and on overlying layers (i.e. waterproofing and surfacing) shall be clarified.

In normal conditions concrete surfaces shall be kept moist at least for seven days. Surfaces with timber formwork need generally not be sprinkled as long as moulds are kept in place unless they are not dried out excessively by heating or by the sunshine. Any sprinkling after stripping of formwork may be replaced by approvable curing treatment.

4:48 Patching and Repairing

No repairs caused by some reason including surface damages shall be carried out without the permission of the Resident Engineer. The work shall be done in accordance with an approved plan by using appropriate methods. "The Directions for Repairs and Patching of Concrete" issued by RIL shall be followed, when applicable. These directions shall apply also for closing of holes and recesses left in structures.

The adequacy of patching and repair materials important in view of the strength of the structure shall be ascertained by tests made during the work. If necessary, advance tests shall also be made to ensure correct proportioning and to find the correct colour for patching exposed to view. More detailed directions for tests will be given by the Resident Engineer.

Local uneven spots in concrete surfaces underneath the waterproofing of the bridge deck may be repaired by appropriate concrete mix proportioned to correspond to the strength of concrete of the deck. Patching shall be carried out as soon as possible after stiffening of concrete. Should concrete have hardened, the cement paste layer shall be removed from the spots to be patched. Even otherwise, directions for construction joints shall be followed when applicable in order to ensure bonding of the patching mixture (Cf. 4:46). Corners and angles may also be rounded off for waterproofing in this connection.

Evaporation from spots patched with concrete shall be prevented by means of efficient waterstops. Patchings important in view of strength shall be kept moist for not less than two weeks and other spots for at least one week.

4:49 Grouting of Anchorage Bars

The diametre of the hole left or drilled in concrete or rock for steel bar shall be about 1.5 times the diametre of the bar. Prior to grouting, the hole shall be cleaned by compressed air, washed with water and if possible dried out by compressed air. The hole shall be filled with mortar using a pressure hose the end of which shall be kept at the bottom of the hole during filling. Pumping of mortar shall be continued while the hose is slowly extracted. After this the steel rods shall be pushed in place. In grouting prestressed anchor steels the directions included in the method concerned shall be followed.

The water/cement ratio of mortar shall generally be ≤ 0.50. Fine-grained aggregate may be used in mortar provided that it will not prevent pushing of steels down to the bottom of the hole. When prestressed anchors are used and even otherwise when separately required, directions for prestressed concrete structures shall be followed in proportioning and mixing of grouting mortar. Tests provided on these Directions shall also be made.

4:5 Checking Properties of Concrete

4:51 Advance Tests

For concrete mixtures made on the site advance tests shall be made when necessary, to determine the correct proportioning in view of the strength and other properties of concrete. In connection with advance tests even such properties of mix as are necessary in planning hauling, pouring, compacting and other operations shall be clarified.

The intended strength in advance tests shall be not less than 1.2 times the design strength. This intended strength may be reduced only when the effect of dispersion on the reference strength has been determined by tests during the work. On the other hand, at the beginning of work the proportioning strength may be rectified in comparison to that used in advance tests in proportion to the deviation of the average results of advance tests from the proportioning strength used. Unless additives are used, advance tests are not normally needed for all strength categories of concrete to be used.

In advance tests the plasticity of concrete mix - average of three tests - shall be, at an accuracy of half the plasticity range (i.e. plastic = 3...5°VB), the same as intended in proportioning. When additives are used and even otherwise when necessary, for example, when the plasticity of the mixture shows a larger deviation than prescribed above, advance

tests shall be made in order to find with the largest possible accuracy the relation between the quantity of water corresponding to the desired plasticity and workability and the proportioning method used, in other words, the water correction coefficient.

Advance tests for compressive strength may be made with approved and inspected equipment also on the site in the presence of the Resident Engineer or a person appointed by the same. Test samples may be compressed at an age of not less than 7 days if normally hardening Portland cement is used. In other cases, concrete shall have attained at least 80 % of its intended strength before test specimens are compressed. The minimum side length or the diametre of test specimens shall be not less than 15 cm.

If directions have been given for the use of air-entraining agents in order to improve the resistance to salts and frost, advance tests shall be made to prove the amount of small pores resulting from the use of such an agent. Unless otherwise provided on the Plan the proportion of entrained air (mini-air volume) shall be not less than 3 % of the volume of concrete. In the test the total air volume shall be determined from concrete batches prepared with and without an air-entraining agent. The proportion of the combined volume (in litres) of water and air and the quantity of cement (kg) as well as the time of mixing and compacting shall be similar in both batches. The additional volume of air is the difference of measured overall air volumes.

Separate directions will be given for each case on making frost resistance tests at an official research institute.

4:52 Tests for Adequacy and Quality Control

In order to ascertain the attainment of design strength for concrete prepared on the site, adequacy tests shall be made as set out on the Standard Specifications for Concrete. Separate directions will be given for each case for testing other properties such as impermeability.

Quality control tests are obligatory for bridge structures. Like advance tests quality control tests during the work may also be made on the site.

In order to define the compressive strength, the number of quality control tests shall be at least half the amount of corresponding adequacy tests. The number of specimens shall be larger at the initial stages of work and always when essential changes have been made in proportioning. More detailed directions for the preparation of test specimens will be given by the Resident Engineer.

In order to check the volume of entrained air achieved by an air-entraining agent, the overall volume of air shall be measured always when pouring is commenced and even when test samples are taken for adequacy and quality control testing. In the comparison, the overall air volume measured from concrete prepared without an air-entraining agent in advance tests shall be used as reference. Tests during the work

TEST SPECIMEN PROGRAMME
QUALITY CONTROL

S I T E :

Pouring project (Structure section(s), if necessary, a drawing	Quantity of concrete (m^3), quality and strength category	Pouring days (dates)	Symbol of proportioning Proportioning strength	Compressive strength tests					Tests of other properties			Notes
				Symbol	Quality Compression age	Result of compression test	K_{28}	Symbol of reference group	Symbol	Type	Result	

15.12.1970

TEST SPECIMEN PROGRAMME

S I T E :

ADEQUACY CONTROL

Pouring project (Structure section(s), if necessary, a drawing	Quantity of concrete (m^3), quality and strength category	Pouring days (dates)	Symbol of proportioning Proportioning strength	Compressive strength tests					Tests of other properties			Notes
				Symbol	Quality Compression age	Result of compression test	K_{28}	Symbol of reference group	Symbol	Type	Result	

should be made by using, with the largest possible accuracy, the same method as in advance tests.

Separate directions will be given for each case on quality control tests concerning the impermeability of concrete.

4:53 Test Specimen Programme and Analysis of Results

The test specimen programme included in the Concreting Plan shall be prepared separately for adequacy and quality control tests. Both programmes shall be prepared by applying the attached forms.

For calculating the amount of test cubes the pouring projects with the quantity of concrete shall be marked in the Table arranged by structural sections. The number and symbols of adequacy test specimens shall be determined in advance for the whole work. Quality control tests shall proceed from one pouring site to another. No similar symbols shall be used in adequacy and in quality control tests.

When the number of test specimens is determined as set out on the Standard Specifications for Concrete, account shall be taken of the fact that there shall be at least six (6) test specimens for each quality and strength category in the pouring sequence. At least one test specimen for each property to be checked shall be taken from each special mixture and from each separate pouring.

In conformance with the Standard Specifications for Concrete, test specimens taken for adequacy tests shall be

compressed at an age of 28 days. It is generally an advantage that the results of quality control tests are obtained earlier. Unless the strengthening process of test cubes is accelerated by special methods, the cubes shall be compressed at an age of at least 7 days. If special methods are used, testing shall be carried out with expertise and care, and the relation of compression results to the 28 days' compression strengths shall be reliably ascertained, for example, on the basis of extensive reference material. The size of any deviations shall also be determined.

Comparative strengths shall be calculated from test results as set out on the Standard Specifications for Concrete. When the comparative strength of adequacy tests is calculated, continuous pouring sections are of decisive importance to grouping of test results. If there are in one quality and strength category more than 24 test results per each pouring section, grouping shall be subdivided by structural sections. In uncertain cases the grouping of test results shall be determined by the Resident Engineer. It shall be borne in mind in the calculation of comparative strength that six (6) test results is the minimum from which the comparative strength may be calculated with a statistical probability of some kind.

In quality control tests the strengths of test cubes shall be assessed in sliding groups. Results of test specimens compressed at approximately the same age may only be included in the same comparative group which shall generally

consist of 6-12 test results representing the strength and quality category concerned. When new test results are obtained, a corresponding number of results is omitted from among the oldest results. The dispersion and comparative strength are calculated as for adequacy tests.
Alternatively, a test value may be determined:

$$\frac{K_m - K_t}{T}$$

in which K_m = the average of test results in the group, K_t = the intended strength and T = the difference between the largest and the smallest test result within the group. Results can best be presented in the form of a graph (Cf. Explanations of the Standard Specifications for Concrete, 1965, Fig. S 34:8). Even other methods of analysing the results of quality control tests may be used if permitted or requested by the Resident Engineer.

If necessary, similar summaries may also be prepared about tests made for checking other properties of concrete.

When proportioning is rectified on the basis of quality control tests, the accuracy of test results shall always be taken into account. As for compression age, the lower the age the larger the obvious error.

4:54 Checking Properties of Prefabricated Concrete

In order to ascertain that the design strength has been attained the adequacy tests of prefabricated concrete shall

be the same as for concrete prepared on the site, and these tests shall be made on the site by the contractor. The amount of test specimens shall also be the same as set out in the regulations for concrete prepared on the site unless otherwise agreed, for example, for large job sites (concrete $\geq$ 500 m^3).

In accordance with the Standard Specifications for Concrete the manufacturer shall be responsible for quality control. Separate directions will be given for each case on quality control tests to be made for checking the properties of concrete by the purchaser.

The purchaser shall however continuously check the elasticity and any pore content of concrete mixture. In order to find the proportion of entrained air in concrete containing an air-entraining agent the manufacturer shall reliably clarify the proportion of air in concrete of a corresponding strength category containing no air-entraining agent. The following method may be used in practice: The proportion of entrained air is clarified at the plant (Cf. 4:51). The overall quantity of air at pouring site is measured from the same mixture containing an air-entraining agent. Assuming that small pores resulting from the use of an air-entraining agent do not disappear during hauling and handling, only the overall volume of air at pouring site is then checked. The overall quantity of air determined of the reference mixture on the site by this method is taken as the requirement.

4:55 Checking Strengthening Process

If necessary the strengthening process of concrete shall be checked by making temperature observations from concrete structures. The measuring points are determined more closely by the Resident Engineer. On the basis of observations and the results of adequacy and quality control tests the strengthening process may be assessed, for example by the method given in Item S24:(4) of the publication "Explanations of the Standard Specifications for Concrete" 1965.

When separately provided or when the requirement has been given in the Standard Specifications, a sufficient number, at least six (6) test specimens shall be made and stored on the site in order to determine the time for stripping the formwork and scaffolding and the time for prestressing. There shall be at least three (3) test specimens compressed at one and the same time. These specimens shall be recorded in the Test Specimen Programme for quality control. Tests may be made on the site as quality control tests unless otherwise provided on confirmed Standard Specifications.

4:6 P r e s t r e s s i n g a n d G r o u t i n g

4:61 Plan

A detailed plan shall be prepared for prestressing and grouting. The plan shall be submitted for the approval of the Resident Engineer unless other directions have been issued for checking and approving the Plan. The supervisory staff and

any experts shall be clarified in this connection, too. The working plan shall be based on the prestressing programme (tensioning plan) prepared by the designer. The Chief of Concreting Works of prestressed structures responsible for the preparation of the working plan shall ensure that in calculating elongations and forces the designer has used the correct coefficient of friction, modulus of elasticity and grip set of anchorages.

4:62 Preparations

Prestressing may be started only with the permission of the Resident Engineer. Prestressing may be started provided that the following measures have been taken:

- it has been ascertained that the required strength of concrete has been attained
- all sections of the structure have been checked and any defects repaired
- installation of anchors has been checked
- parts of scaffolds obstructing longitudinal movements of structure have been removed
- installation clamps of roller bearings and similar have been removed
- prestressing equipment and any separate gauges to be used have been reliably checked
- the working plan has been approved.

Prestressing equipment shall be checked always when moving over to a new site and even otherwise frequently enough.

This may be done so that a prestressing cable (tendon), the properties of which are accurately known is pulled under conditions in which the effect of external factors on the elongation can be determined with sufficient accuracy. There shall be at least six (6) measurements. The average deviation with full stressing force shall be taken into account in prestressing. Equipment with extreme values deviating by more than $\pm$ 5 % of the average shall not be used. The accuracy of gauges shall be in proportion to the required accuracy.

4:63 Prestressing

The work shall be carried out in accordance with an approved Plan. On the basis of observations made during prestressing, the Plan shall if necessary be revised or amended. The regulations for the Plan shall also apply for the approval of revisions.

Elongations during prestressing should be kept within the range of tolerance calculated for the work. Prestressing force shall always be determined by measuring of either force or of pressure. When the force exceeds the theoretical value of 5 %, prestressing shall forthwith be ended although the calculated elongation had not been attained. The causes for the deviation shall be found out. If on the other hand the force, after the calculated elongation has been attained, is more than 5 % lower than the theoretical value the causes shall be clarified and any additional prestressing needed shall then be carried out.

Records shall be kept of prestressing by using an approved form. Among other things, the following data shall be recorded:

- site
- section of structure
- dates of prestressing and (grouting)
- temperatures of structures and air during prestressing (and grouting)
- prestressing method
- type symbol of cables (tendons)
- steel quality and measured modulus of elasticity
- type markers and numbers and basic values (i.e. effective area of piston) and accuracy of prestressing equipment
- number and prestressing sequence of cables
- calculated elongation, force, manometric pressure etc.
- measured elongation, force, manometric pressure, grip set of anchorage etc.
- net elongation determined on the basis of measurements
- any markings concerning grouting
- the column for "Notes" may be used to give data, among others, on the reasons why elongation and force are not equal to calculated values; for example, deviation of measured areas of prestressing steel from nominal values, or reference to separate clarifications
- the records shall be confirmed by the signature of the responsible foreman and the Resident Engineer
- the form shall also contain a column for approval.

In the determination of elongation the straightening of loose

steels at the initial stage of tensioning shall be taken into account by means appropriate for each method. If owing to the adjustment tolerance of anchoring device or to some other reason the span has to be moved inside the casing, such a movement shall be accurately determined. If necessary, tensioning shall be removed from the both ends and recommenced from the beginning.

Grouting with preceding water jetting of sheathing tubes shall not be commenced and measures preventing re-tensioning shall not be taken before prestressing has been approved.

4:64 Grouting Mix

The quality and mix proportions of materials, cement, water, additive and any aggregate of grouting mix shall be clarified.

In preparing the mix, dry materials shall be weighed and liquids measured by volumetric measurement at an accuracy of ± 2 %. By tests and test specimens it shall be ensured that the capacity of the mixer is sufficient. The mixer shall be filled in the following sequence: water, cement and any aggregate. Powder-like additives shall be added in the middle of mixing. The effective mixing time shall be not less than four (4) minutes.

Unless the properties of the mixer and the mix to be prepared are known on the basis of advance tests or when separately requested, advance tests shall be made. Tests and test spec-

imens made of the mix shall conform to the Standard Specifications.

The volume of mix shall not during a period of 24 hours decrease by more than 2 % or increase by more than 10 %. Grouting mix may be considered frost-proof if the volume of test cube decreases linearly when the temperature drops to about -5°C. Below that temperature the decrease of the volume shall continue linearly but stronger than above the same temperature.

During the work three test specimens per each 1 000 litres of mix shall be taken from grouting mix for strength tests. Unless the advance tests provided above have been made, even other properties of the mix shall be determined by testing during the work. Such tests shall be made at least once during each separate prestressing operation at an initial stage of work. When agreed separately the frost-resistance test may however be omitted. Tests of test specimens shall be made at an approved material testing institute.

4:65 Grouting

Grouting shall not be started before the prestressing of the structure, the properties of grouting mix, equipment used and the working plan have been approved. Prior to grouting, sheathing tubes shall be cleaned by water jetting and any oil shall be removed.

The capacity of the grouting pump shall be such that the

speed of mix in a tube smaller than 10 cm in diametre is 6...12 m/min. at a pressure of less than 10 aty. Each cable shall be grouted in one continuous operation. Pumping shall be continued until the mix coming from the outlet pipe is of full thickness. A plan shall be prepared for grouting clogged cables. Grouting equipment shall be fitted with a dynamic pressure valve.

Grouting should normally be carried out as soon as possible after prestressing, particularly if steel is tempered. In grouting during cold seasons steps shall be taken to heat and protect the structure. A separate agreement shall be made for each case on postponing grouting and on the protection of prestressing steel against corrosion.

In planning of grouting it shall be considered whether long and narrow cables should be grouted through an air-release pipe placed in the middle.

Records shall be kept of grouting indicating, among other things, the following data:

- composition of grout
- clarification of adequacy
- mixing and grouting equipment used
- maximum pressure during grouting
- temperature of air, structure and during cold seasons also of mixture
- dates
- signatures
- notes.

It is recommended that markings of cables for grouting are made in the prestressing records.

4:66 Other Directions

Anchorage recesses and any post-grouting openings shall be repaired and any defects in concrete made good by directions given in Item 4:48 when applicable.

Instructions and directions concerning the adequacy control and installation of prestressing steel have been given in Item 4:3.

Release of clogged cables shall be carried out in accordance with an approved plan.

4:7 Dismantling of Scaffolding and Formwork

Scaffolds and formwork should not be stripped at once after the strength of concrete set out on the Standard Specifications for Concrete has been attained unless of significant advantage in view of the arrangement of works. It is the form work that effectively prevents moisture from evaporating from the surface of concrete.

When the date of dismantling formwork is determined, account shall be taken, in addition to the average strength of concrete, also to spots not so well hardened. Unless the relation between the loading during stripping and the design loading as well as the extra stresses resulting from strip-

ping are clarified, the average strength of concrete at the time of stripping shall generally be at least 90 % of the design strength.

Prior to stripping load-carrying parts of scaffolding care shall be taken to ensure that there are no such concreting or other defects in load-carrying structures as may be dangerous from the point of view of the durability or as have to be repaired for other reasons before load-carrying scaffolding is dismantled. Load-carrying scaffolding of prestressed bridges may be stripped only when the prestressing has been approved.

A permission of the Resident Engineer is always required for stripping of formwork and scaffolding. The work shall be carried out systematically and directions provided in the Scaffolding Plan or given by the designer of the bridge shall absolutely be followed.

In connection with trimming all remains of shuttering, tie rods, wires and nails shall be thoroughly removed from concrete surfaces. The heads of steels shall be cut off flush with the concrete surface and painted in the colour of concrete. Polystyrene used as fill shall be removed from visible joints.

4:8 Facing of Concrete Surfaces

4:81 Ordinary Stone Facing

Unless otherwise provided on the Bridge Plan an ordinary

stone facing shall be constructed as set out in the attached Drawing. Stones used shall be of high quality, uniformly coloured granite and preferably light-toned. The length of stones shall be equal to or larger than the height. The height in one layer shall not vary by more than ± 0.5 cm. Vertical joints shall be staggered. If stones are of equal dimensions, joints should be placed in the middle of stones in the underlying layer.

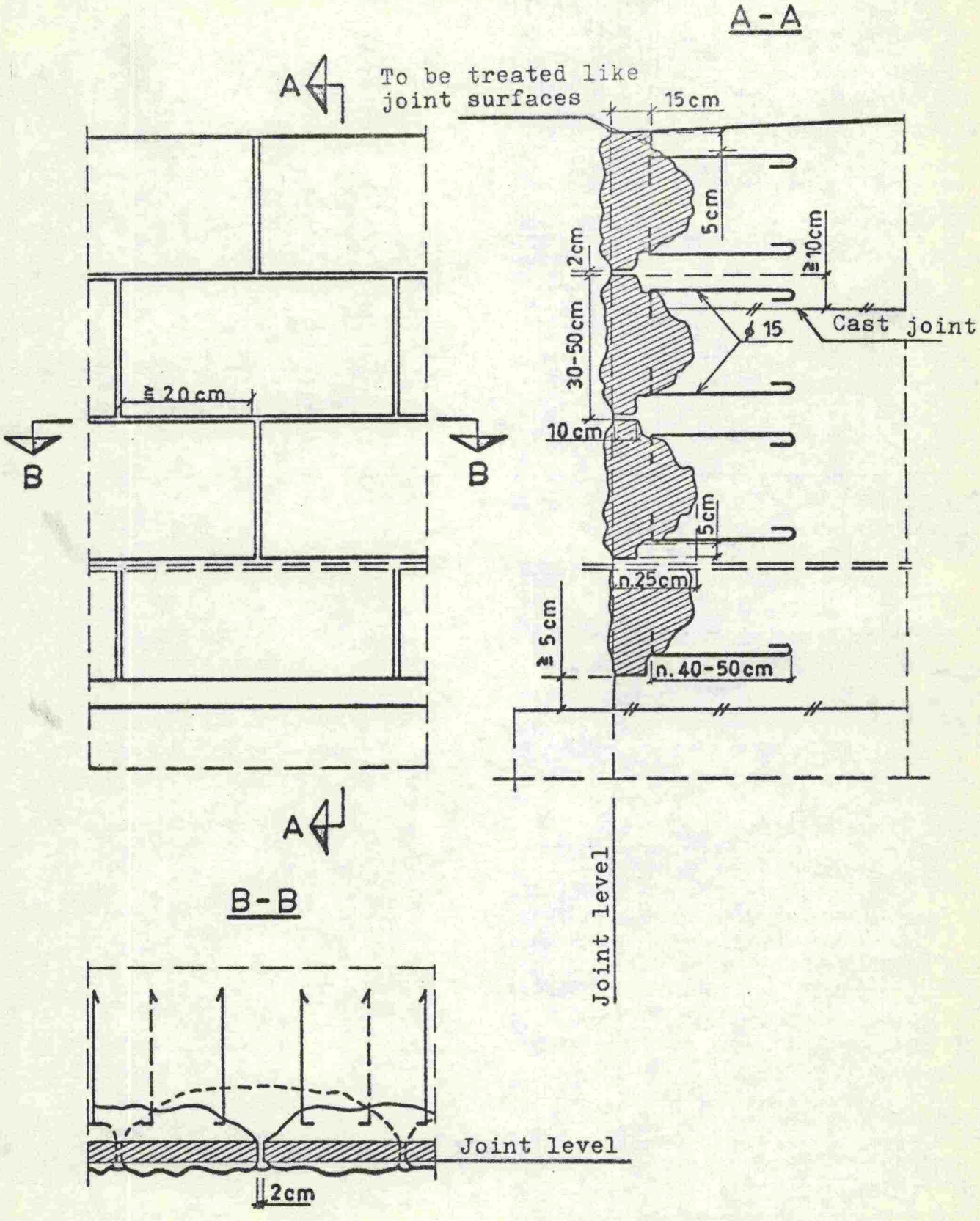
Surfaces exposed to view may be dressed, mainly non-handled, rough with edges on the same level or conforming to some other form set out on the Plan. Cavities extending below the level of the joint are not allowed. The bumps of the surface raising above the level shall be not more than 5 cm high. Drill and wedge marks etc. are not allowed (Cf. RT 302.3/1963).

Surfaces at joints shall be chiseled, dressed with a cross-head dressing hammer, degree I in which the maximum hole depth is 1 cm or grossly cut (Cf. RT 302.3/1963). The surfaces shall be straight.

In placing stones, 3/4" x 1" jointing battens shall be used. Joints shall be tightened in such manner that concrete will not penetrate through the joint to a significant extent. Pieces of steel, concrete, plastic and stone may be left in place as wedges. Stones shall be supported to allow for pouring pressure. There shall be at least four (4) anchorage bars per stone with a spacing of not more than 100 cm.

ORDINARY STONE FACING

1:20



Prior to concreting the surfaces and joints facing concrete shall be thoroughly cleaned. There shall normally be at least two stone layers between cast joints. Special attention shall be given in pouring to the fact that concrete mixture penetrates to the joint battens. After hardening of concrete battens shall be removed and the joint shall be trimmed with concrete mortar. On surfaces exposed to changes of water level and to waves, air-entraining agents shall be used in mortar to improve the frost-resistance of joints. During the work, stones shall be protected and after pouring cleaned, if necessary.

4:82 Smooth Stone Facing

A smooth stone facing differs from the ordinary type as follows:

- visible stone surfaces shall be dressed as joint surfaces in Item 4:81.
- the diametre of bond steels shall be 22 mm and the spacing not more than 50 cm.

4:83 Other Facing Types

A detailed plan and directions for other types of facing are given in connection with the Bridge Plan.

4:84 Other Directions

The iceguards of piers with stone facing may, when pouring a pier, be separated by a construction joint from the other

structure and cast afterwards in layers as set out on the Drawing of Stone Facing. In handling construction joints, directions given in Item 4:46 shall be followed. The location of joints is determined by the Resident Engineer unless indicated on the Drawings.

4:9 Prefabricated Structures

4:91 General

Prefabricated concrete structures shall be made in accordance with approved drawings. In manufacturing, hauling, erecting and jointing prefabricated structures the Standard Specifications for Concrete and Prefabricated Structures and supplementary specifications as well as directions on various work stages of cast-in-place structures shall be followed when applicable.

Cast-in-place structures may be replaced by prefabricated structures only with a separate permission.

The permissible tolerances shall be clarified prior to manufacturing prefabricated structures.

4:92 Prefabrication

The results of the adequacy and quality control tests of concrete used in prefabricated structures shall be presented in a clear way to the Resident Engineer. Particularly when various hardening processes or additives are used in order

to accelerate hardening it shall be verified by means of test specimens and calculations based, i.e. on the time-temperature function that the strength requirements specified for concrete in various stages of work are satisfied. In prefabrication, high pressure steam hardening may be used only with a separate permission provided it is shown that the process will not be detrimental to the strength of concrete or to bonding and anti-corrosion properties of steel.

Surfaces exposed to view shall generally be roughened. For example, rough rubber sheet against the formwork or brushing are recommended. Soffits of structures higher than 2.5 m above the roadway may be and all upper surfaces shall be left unroughened. The surface treatment of one and the same bridge shall be uniform unless otherwise agreed for particular reasons.

The moulds shall be in good condition and clean so that the surface of structures will be faultless and that the required accuracy and straightness are achieved. The use of shutter oil shall not result in strains on prefabricated structures.

As for the accuracy of installing reinforcement directions given in Item 4:33 shall be followed, however so that reinforcement including stirrups and additional steel bars shall at no spot be closer than 2.5 cm to the surface of concrete.

Lifting loops should be placed on surfaces not exposed to view. The loops shall be cut off at least 2 cm inside con-

crete and the mark shall be rubbed off as prescribed in Item 4:48.

The manufacturer can place his trade mark on a location agreed separately. The trade mark shall be made in concrete by pressing and it shall not be too conspicuous.

4:93 Handling and Erecting

During all stages of handling, concrete shall have the required strength including factors of safety set out on the Standard Specifications. Handling and storing prefabricated sections shall be arranged so that they will not be stained or damaged. Special care shall be taken to ensure that the foundation of storage has a correct form. The location of supports to be placed between prefabricated elements shall be determined in advance so that there will be no stresses not considered in the design of elements.

The erecting plan shall be prepared in advance and submitted to the Resident Engineer. If required, the stresses of concrete and steel during various stages of erecting shall be indicated by calculations. The stability of prefabricated structures shall also be studied. If possible the actual dimensional deviations of structures shall be taken into account when the tolerances of erecting are determined. The deviations shall be balanced in such manner that no detriment willbe caused to the strength and appearance of the structure. Special attention shall be given to the straightness of lines and surfaces exposed to view.

Erecting shall be completed in one continuous operation in order to prevent damages or stains by weather before joints and other exposed parts can be protected.

4:94 Jointing

Unless otherwise agreed advance tests shall be made of load-carrying jointing compounds. The compressive strength of hardened mortar shall be studied on the basis of these tests.

Separate directions will always be given for studying other properties such as resistance to frost. In order to determine the compressive strength of concrete one test sample per each new 1 000 litres shall be taken during the work. The shape of samples and the performance of tests may generally be in conformance with instructions and directions concerning grouting mixtures. Testing shall be carried out at an official research institute.

When cement paste or concrete mix is used for jointing, directions on the preparation of concrete and grouting mixture shall be followed, when applicable, in the preparation of and jointing with such materials. Proportioning shall be as normal and it shall be submitted for approval before the work is commenced. Joint surfaces shall be thoroughly cleaned, for example, by compressed air and brushing. Joints shall not be sprinkled. Evaporation from jointing compound after jointing shall be prevented. In cold weather the temperature of mortar shall be at least +5°C and not more than +40°C. At temperatures below -1°C or if such temperature is antici-

pated during jointing or in the next few days, the structures shall be heated so that the jointing compound will not freeze until having attained the so-called freezing strength. A special permission is required for electrical heating.

Separate directions will be given on the use and preparation of other jointing compounds such as materials based on bitumen and plastic.

4:95 Other Directions

Damaged elements shall not be fixed into structures without a permission of the Resident Engineer, although the damages were of minor scope. Broken parts may be repaired only by an approved method. There shall however be no unsightly patches on surfaces exposed to view.

5: STEELWORK

5:1 G e n e r a l

5:11 Plans

In view of preparing steelwork only the assembling drawings are generally given in the Bridge Plan. The accurate dimensions and material specifications of all parts are indicated on these Drawings and/or in the List of Parts. The manufacturer shall prepare any additional drawings of parts, if deemed to be necessary by him.

The manufacturer shall prepare a detailed erection plan and submit it for approval prior to the commencement of erection or of preparatory works.

5:12 Tolerances

Dimensional tolerances not given on the Bridge Plan or General Specifications shall be determined by the manufacturer. The tolerance of parts shall be selected in view of requirements for the strength, operation and overall dimensions of the structure.

5:13 Standard Specifications

Besides the Plan and General Specifications, Finnish Standard Specifications shall be followed. Lacking these, applicable foreign specifications shall be used, of which however,

a separate agreement shall be reached for each case.

5:2 M a t e r i a l s

5:21 General Requirements for Quality and Preparation

With exceptions mentioned later herein the quality requirements shall conform to the Standard Specifications for which a marking has been given on the Drawings. Even other directions may however be given in the Bridge Plan and/or other Documents on the quality requirements of materials.

As for the manufacturing method, steel used in welded structures shall be M (Siemens-Martin), E (electrical smelting) or Y (oxygen blowing) steel. The Y-method may be approved provided that the steel plant can also be accepted. In secondary parts the W-quality conforming to DIN 17100 may also be approved. Steel to be used in the most important welded structural members shall be killed and steel in other welded structures at least semi-killed.

5:22 Ascertaining Adequacy

Prior to the start of works the usability of materials shall be shown by tests and manufacturer's certificates. The shipment shall be specified in such manner that it may unambiguously be ascertained on the basis of certificates and markings on steel sections to which smelting charge each section belongs. Sections marked deficiently may be rejected or tests may be required separately for each section.

In ordering for steel, account shall be taken of the fact that the number of tests prescribed in the Standard Specifications or other documents to be followed can be made. Test samples shall be ordered as excess lengths of sections. Separate test samples shall not be approved. Test samples shall also be taken into account in cast sections.

Test samples shall be marked in the presence of the Resident Engineer, using the symbol specified by him. The manufacturer may remove test samples and work them into test bars specified in the Standard Specifications. Tests shall be carried out at an official research institute or elsewhere in the presence of the Resident Engineer, provided however that in the latter case official inspection certificates are available of equipment used.

In general, the number of tests of delivery shall be not more than that set out on the Standard Specifications. For particular reasons even a larger number of tests may prove necessary, for example if there is reason to suspect the uniform quality of a delivered steel shipment. Separate directions will be given for each case on the number of tests of rivets and bolts and other special members.

Precautions shall be taken in order to make the following tests of steel sheets and sections:

- tensile test, both longitudinally and transversally for sheets
- bending test, for sheets only in transverse direction
- impact test if a requirement for resistance to impacts has

been prescribed in Standard Specifications or other documents. Unless otherwise agreed the impact test of sheets is made only in transverse direction

- spectral or Quantovac analysis of each test bar of the tensile test, however only one test of the same sheet and not more than three tests of the same charge
- welding test if provided on the Standard Specifications or other Documents.

5:23 Testing and Results

Unless otherwise agreed tests shall be made in conformance with Finnish Standards, DIN or SIS Standard Specifications.

The impact test shall always be made by using a Charpy-V-notch. Unless a lower temperature is prescribed in the Standard Specifications or in other Documents the testing temperature shall be $\pm$ 0°C. In addition to the requirements of impact resistance as an average of three tests, individual test results shall not be less than 2.5 kpm/cm^2.

In the spectral or Quantovac analysis, at least the following elements shall be observed: C, Si, Mn, S, P, Cr, Cu, Al, V and Ti. Nitrogen (N) shall be determined in wet analysis by random tests if the permissible maximum quantity of nitrogen has been given in the Standard Specifications.

If some of the tests will not show approvable results, two new tests shall be made of different units. The new tests shall conform to specifications. A section, the results of

which do not meet the requirements shall be rejected although the remaining stock were approved on the basis of new tests. In case that the first test is suspected to be defective, a new test of the same section may be considered.

5:3 Directions for Workshop and Erecting Work

5:31 Alignment and Cutting

In measurements of parts the temperature and correction factors of measuring tape shall be taken into account. Unless otherwise mentioned, the dimensions on Drawings are given in a theoretical erection temperature of $\pm$ 0°C. Shrinkage resulting from welding has not been included in Drawings unless separately mentioned. The risk of shrinkage shall be determined on the basis of experience.

Alignment and cutting shall be carried out so that there will be no detrimental stresses or notches impairing the strength of the parts.

5:32 Riveting

In Drilling or punching for holes the parts shall be fixed into one another tightly. In riveted structures, bridging welds shall not be used without a permission of the Resident Engineer. Prior to riveting, mating surfaces shall be cleaned and painted with one coat of primer.

5:33 Welding

Welding may be carried out only by skilled welders who have passed the qualification test. The operators of automatic welding equipment in particular shall be qualified. In welding secondary seams, welders not passing the test welding of Category 4 or lower may be used only with a separate permission of the Resident Engineer. The qualifications of labour shall always be kept up-to-date.

The welding site shall be protected against rain, snow and wind. At temperatures below $0^{\circ}C$ welding shall not be carried out without the permission of the Resident Engineer. The permission will be granted provided that the welding site will be surrounded by a heated cover, that pre-heating is provided or that other necessary steps are taken. In all weather conditions care shall be taken to ensure that the seam to be bridged or welded is dry and clean and that electrodes are dry.

Welding electrodes shall be selected to suit the basis material and the work. Welding sequence shall be prepared in view of minimizing stresses resulting from welding. Thin electrodes should be avoided if roughening is to be anticipated owing to conditions, material thickness and/or strength of material.

All welds shall be inspected ocularly. X-ray photos shall be taken of butt welds. Unless a full film is required for certain seams, random films shall be taken (Cf. Standard Speci-

fications for Welded Steel Structures, Item 6235). Furthermore, ultrasonic and other studies may be carried out.

X-ray films shall be assessed in accordance with IIW (International Institute of Welding) classification. In bridge structures at least category 4 or "blue" is required. The weld run shall be even and smooth. Detrimental unevennesses shall be repaired by grinding. The legs of fillet welds shall be of the same length unless otherwise provided on the Drawings.

5:34 Friction Joints

Finnish "Temporary Directions for Friction Joints of Steel Structures" shall be observed. In special cases if the plan has been prepared on the basis of foreign specifications it may be agreed that the work shall be carried out in conformance with them. Even in these cases, however, Finnish specifications should generally be applied.

In bridge structures to be constructed in accordance with these Specifications the surfaces to be jointed shall be sand blasted. The degree of cleaning shall be Sa 2 or better in accordance with the IVA classification. With a permission given separately, smaller and less strained joints may be flame cleaned. In addition to oil and grease, paint shall also be removed by solvents prior to flame cleaning.

In bridge structures, bolt holes shall not be made by punching. Torque wrenches that shall be officially inspected

shall be calibrated by torque values to be applied. Inspections shall be made daily in the presence of the Resident Engineer.

The values of wrenches actuated by compressed air shall be determined by tests at an official research institute, in which the elongation and consequent prestressing force shall be measured of bolts to be used in structures. A determination of this kind shall be made always at the beginning of the work and afterwards at least once a year. The tightness of bolts (at least three) driven by these equipment shall be inspected daily by a calibrated torque wrench.

A friction joint shall not be closed before the Resident Engineer or a person appointed by him has checked that contact surfaces have been treated as specified. The Resident Engineer shall also attend the inspection of the prestressing of bolts.

5:35 Transport and Erecting

For transport, structures shall be supported and protected in order to prevent detrimental deformations and staining to an extent not possible to clean thoroughly.

In hauling sections the location of lifting or supporting devices shall be carefully considered. A permission of the Resident Engineer is required for fixing lifting lugs and for making extra holes in the section. Such measures shall not impair the strength of the structure. Marks of welds

shall always be ground even.

Welding of load-carrying structures on the bridge site is prohibited without a separate permission. A permission will be granted provided that circumstances during welding are as specified in Item 5:33 above.

Unless otherwise agreed the structure shall be test-assembled either at the plant or in the vicinity of the bridge site prior to the final erection. At this phase joints should be adjusted to final position so that rivet or bolt holes may be drilled to the final size. In any case care shall be taken in assembling sections to ensure that there will be no bends at joints or stresses not included in the Bridge Plan.

If steel sections have been cleaned and painted with primer before assembling, damages to paint shall be avoided. Immersing painted sections into saltless water for a longer period and even a shorter immersion into sea water or into water containing industrial waste is forbidden. Braided steel ropes shall not be immersed even in non-polluted water.

5:4 C l e a n i n g

5:41 General

This Item of the General Specifications shall be observed in cleaning new steel structures for painting, galvanizing

or other protection against corrosion and in treatment of contact surfaces at friction joints. These directions shall be observed in cleaning of old structures, when applicable.

5:42 Removal of Grease

At the first stage greases, oils and similar impurities shall be removed either by organic solvents or by detergents having effect on such materials (Cf. Item 5:34).

5:43 Sand-Blasting

Prior to painting, all surfaces shall be cleaned by sand-blasting. In removal of thicker rust layers, rust chippers and scrapers shall also be used. Should sand-blasting of some individual parts prove specially difficult, flame cleaning and wire brushing may also be permitted as specified hereinafter.

Blasting material shall be dry and clean sand, grain size about 1 mm and the maximum grain size 1.5 mm.

In comparing the degree of cleaning, the scale set out in SIS 055900 (IVA) shall be used. The thoroughness of cleaning shall be assessed immediately before painting is started by comparing the cleaned surface with photographs given in the Standard Specifications mentioned above. Should this method be considered too ambiguous by both parties, one or more steel plates of about 50 cm x 50 cm may be cleaned as references. The reference sheets shall be stored in a dry

and warm room in which no corrosion will develop. If necessary, new reference surfaces shall be prepared.

The degree of cleaning Sa 2 is sufficient for primers based on/
so-called drying oils and for friction joints (Cf. 5:34). A lower degree of cleaning is not approved in bridge structures. The cleaned surface shall be free from mill scale and rust. Only the bottoms of indentations may seem dark. The colour of the surface may be a little darker than that of a shining metal surface.

The degree of cleaning Sa 3 is required for primers, the anti-corrosion effect of which is based on so-called cathodic protection (i.e. zinc dust primer). The cleaned surface shall be thoroughly shining.

A degree of cleaning approximately between Sa 2 and Sa 3 is required for all other primers based on chemical reacting binders and for primers based on alkyd and chlorinated rubber media. In this case reference plates shall always be prepared. The representative of the paint factory may be heard as an expert.

Painted surfaces shall not be damaged by sand-blasting. Sand used in blasting shall not be blown on newly-painted surfaces.

Blasting with steel or other durable grains is regarded as equivalent of sand-blasting.

5:44 Flame-Cleaning

There are restrictions as to the use of this method (Cf. Item 5:43).

Flame-cleaning shall be carried out by means of oxy-acetylene flame by using an appropriate jet. The recommended excess of oxygen is about 30 %. Special care shall be taken in this method to prevent damages by heat to the cleaned structure.

In removing thick layers of rust, chippers and scrapers shall also be used. The speed of the jet and the number of treatments shall be suited to the size and the amount of rust of the sections to be cleaned. Burnt waste shall be removed with wire brushes, soft wire brushes or similar at friction joints. A thorough flame cleaning may be considered to correspond to the degree of cleaning Sa 3.

After flame-cleaning, painting shall not be carried out on a surface warmer than +70°C. When special primers are used, the temperature should be negotiated with the manufacturer (i.e. wash primer +30°C).

5:45 Wire Brushing

This method can be used only by a special permission in exceptional cases if sand-blasting or flame-cleaning cannot be used. On the other hand, so-called light coatings of rust appearing after sand-blasting may generally be removed with a wire brush.

Wire brushing shall be carried out as thoroughly as possible. The degree of cleaning shall be St 3 as set out in IVA. Any mill scale shall be removed by other methods in connection with wire brushing.

5:46 Chemical Removal of Rust

So-called rust-removers may be used only with a separate permission. The method may be used only at locations, the cleaning of which would otherwise cause unreasonable detriments and costs. The resulting chemical reaction shall be controllable also under prevailing conditions on the site. The surface treated before painting shall be thoroughly cleaned of waste causing damage to steel and the coat of paint.

5:47 Protecting Clean Surfaces

Cleaning and painting shall be scheduled so that cleaned surfaces may be painted in eight hours after cleaning. The time specified above applies to work performed out-of-doors under dry weather conditions. A longer time may be permitted in dry indoors conditions, however not more than 24 hours. In any case, priming shall be performed before any rust-formation is observed.

If necessary, pre-treatment (Wash primer, Haftgrund) may be used. A film of about 5 µ is considered to give sufficient protection against rust for not longer than two weeks during which actual priming shall be carried out.

As for friction joints, directions on the same shall be observed.

5:5 P a i n t i n g

5:51 Paints and Coat Thicknesses

Appropriate paints and putties shall be used. If necessary, tests shall be made to assess the quality and adequacy of paint materials. In selecting paints the following factors shall be considered:

1) suitability for bridges (humid climate, resistance to weather of primers etc.), 2) adequacy of all paints when used upon one another (solubility, drying, adhesion etc.). It is generally preferable that paints of one manufacturer are used in all layers. The approval of suggested paint types is affected by experience and reliable test results and reports of the composition and effects of the paints.

When paints based on linseed oil, chlorinated rubber and alkyd binders are used, there shall be two primer and two finish coats, that is, four unifcrm coats of paint. The colour of various coats shall differ in order to improve the control of painting operations.

The combined thickness of primer coats shall be $\geq$ 70μ and the overall thickness of the coat of paint $\geq$ 130μ . The values are averages and individual observations may be 10μ lower.

Besides four uniform coats of paint, the spots susceptible to corrosion shall be strengthened. Spots like these include corners, angles, free edges and welded seams and the heads of rivets and bolts. These spots shall be treated once with unthinned primer applied after the first uniform coat of primer. The work may be carried out in connection with so-called patching. In friction joints, strengthening shall be carried out as soon as possible after tightening.

Holes impossible to paint shall be filled with putty. The putty shall be specially suited to the purpose (e.g. suitable for use with selected paints).

At riveted and bolted joints the mating surfaces shall be painted with one coat of primer. The contact surfaces of friction joints shall be carefully protected during painting.

When paint types other than those mentioned above are used, a separate agreement will be made for each case on the number and thickness of coats.

The last coat of paint shall have the tint KY 4, KY 8 or KY 11 in accordance with the General Colour Map I ("Kykartta I") of Anti-Corrosion Paints issued by the Central Society for Chemistry, that is, light grey. On smaller surfaces, aluminium may also be used. Even other directions may be given for the colour in the Bridge Plan or in other Documents.

5:52 Painting

The surface to be painted shall be clean and dry. Remains of blasting sand and other waste shall be thoroughly removed by means of a vacuum cleaner or other efficient device. The temperature of the surface shall suit the type of paint.

The first coat of primer shall be spread by brush unless otherwise agreed. The work shall be carried out with professional skill. Special attention shall be given to corners, free edges and heads of bolts and rivets.

Subsequent coats may be applied by means of high-pressure sprayers without the admixture of air or by means of rollers. In spraying account shall be taken of the toxity and other properties of paints.

Painting shall be carried out only under dry weather conditions. The temperature of air and of the piece to be painted shall be $\geq +5^{\circ}C$ and the relative humidity ≤ 85 %. These directions shall apply to paints based on linseed oil, chlorinated rubber and alkyd binders. When other types of paint are used, the directions of the manufacturer shall be observed.

Generally, paints shall not be thinned. If necessary, the use of thinner may however be approved in a proportion recommended by the manufacturer. It is recommended that the consumption of paint is discussed with the manufacturer and that the consumption is checked continuously during the work.

Priming may be carried out either at the plant or on the bridge site. If, for example, owing to assembly, the steel structure has to remain without a finishing coat of paint for a longer period, so-called weather-proof primer shall be used.

Spots damaged during hauling and assembling shall be cleaned and carefully patched with paint. Priming coat shall be covered by a finishing coat as soon as possible.

5:53 Working Plan and Inspections

A report of painting operations shall be prepared in good time before the work is started. The report shall include the following information:

- paints used
- cleaning methods and places it is performed
- painting method, equipment and device used and the site it is executed
- schedule and its relation to the progress of workshop operations and assembling.

Painting operations shall not be commenced until the Resident Engineer has checked and approved the cleaning of the surface. Always prior to the application of a new coat of paint the Resident Engineer shall check and approve the previous coat as well as any patchings and strengthenings.

Daily notes shall be made in site records about the temperature and humidity of air as well as about inspections.

The above thicknesses of the coat of paint mean values that may be measured by an "Elcometer" or some other magnetic measuring device from the final structure. During measuring the coat of paint shall be dry. The thickness may also be assessed on the basis of the consumption of paint. Even other measuring device may be used.

5:6 Galvanization

5:61 Pre-Treatment

Parts to be galvanized shall be thoroughly cleaned by sand-blasting or by another approvable method (Sa 3). Detrimental edges, cracks, uneven welds and splashes shall also be removed, for instance, by grinding.

5:62 Hot Dip Galvanizing

Hot zinc shall be applied in conformance with the Finnish Standard Specifications of Metal Industry TES 917-98. The classification of the hot-zinc coat shall be Zn k 700 unless otherwise agreed. The quality control, sampling and inspecting shall also conform to the TES Standard Specifications.

5:63 Other Methods

Separate directions will be given for each case on the use of zinc spraying and electrolytic methods.

5:64 Other Directions

Parts to be cast inside concrete shall not be galvanized. At the border, galvanization shall however extend by 2...5 cm inside concrete. When separately agreed, such parts inside concrete may be galvanized the bonding of which is of minor importance.

Galvanized parts shall not be welded or worked unless required by the Bridge Plan. Damaged surfaces shall be repaired as set out in Item 11 of TES 917-98 Specifications.

5:65 Painting Galvanized Surfaces

Should the colour of galvanized surfaces exposed to view, i.e. in guardrails, be too uneven, these surfaces shall be painted. Special paints developed for the purpose may only be used in painting galvanized surfaces.

6: TIMBERWORK

6:1 General

These Specifications primarily apply to permanent timber structures and reserve bridges. When applicable, these directions shall be observed also in the construction of scaffoldings and similar temporary structures.

The strength of timber shall be as set out on the Plan. Unless the strength category has been indicated, timber of at least Category II shall be used in the load-carrying parts of bridges and scaffoldings. Sawn timber shall be sorted as set out in the Standard Specifications for Timber and in the Bulletin No. 93 of the State Institute for Technical Research. Should there be no duly marked timber available, sorting and marking as set out in the Bulletin shall be carried out on the site. The person sorting timber shall be skilled in this task. In sorting other timber, directions on sawn timber shall be followed, when applicable.

6:2 Structures Made On Site

When timber is placed into structures care shall be taken to ensure that the properties of strength, curvature etc. will resist strains as well as possible.

In bent structures the stronger side, that is the side more resistant to tension, shall be placed on the side of tension, which in two-strut beams is on the underside of the girder

and in cantilevers as well as at the struts on the upper surface of the girder. In marked timber the harder side has been marked. As for other timber, the harder side shall be found during the work. Knots and other defects shall be avoided on the side of tension as far as possible. In bent beams there shall be no significant curvature, at least not in the horizontal level or in other level at right angles to the direction of the force.

In structures exposed to tensile stress as faultless timber as possible shall be used. Groups of knots are especially detrimental. Any minor defects shall be symmetrically dispersed.

In structures strained by pressure as straight timber as possible shall be used. The deviation of the centre line may be not more than 0.5 % of the distance between measuring points. Notches and weak spots other than those provided on the Plan are not permitted.

Joints shall be made with special care. Parts shall be placed accurately against one another, particularly in pressed joints. At joints important from the point of view of the strength of the structure thin wedges or chips shall not be used as fill. At pressed joints fill material not provided on the Plan against the fibres of which the pressure is directed at right angles shall not generally be used. Joints of pressed structures shall be fitted accurately in a concentric position.

The holes for bolts shall be drilled accurately to the size of the shank. Although no nailing formulas were given on the Plan, the nails shall be placed in an overlapping pattern in respect of the fibres of timber so that there is no risk of splitting. Should the timber sections split at the joint studies shall be made for the causes and it shall be considered separately for each case whether and by what means the defect shall be repaired.

6:3 Prefabricated Structures

In these Specifications prefabricated structures mean sections prepared in a factory or under similar conditions. The directions given in Item 6:2 above shall be followed, when applicable.

When bridge structures are made of dry timber material, account shall be taken of that conditions will generally be relatively humid. In manufacturing glued structures directions for the moisture of timber given in the Standard Specification for Timber shall be followed. If necessary, tests shall be made or other reliable means shall be used to clarify that the glued structure will not be damaged by the changes of humidity to which it will be exposed on the bridge site.

Weather-proof glues, for example phenolic and resorsinol glues shall be used in bridge structures.

6:4 Preservation

Steps shall be taken during the work as far as possible and within the limits prescribed by the Bridge Plan to place timber sections so that air will freely flow around the sections. If there are more than one layer in the bridge deck, the upmost layer shall be made tight. Water shall be conveyed from the deck so that it will not flow on underlying load-carrying structures. All timber sections and particularly those made of sawn timber shall be separated from concrete, stone and earth fill by means of moisture-retaining layer of, for example, insulating felt or metal sheet.

In permanent bridge structures impregnated timber only may be used. Pine shall generally be the type of timber used. Piles may, however, be of pressure-impregnated spruce. The use of pressure-impregnated round spruce in other load-carrying structures (i.e. in main girders) may be considered provided it may be ensured that twisting will not cause detriments to the carrying capacity or form of the structure.

A reliable method and impregnating compound shall be used. The storing and humidity conditions of timber shall be as advantageous as possible from the point of view of impregnation. The efficiency of impregnation shall be checked, for example, at cut surfaces. Poorly impregnated timber shall not be used in permanent structures.

It shall be borne in mind that timber treated with creosote oil is highly flammable and consequently, such timber shall be avoided in superstructures. It shall not be used in the deck structures of steel bridges without a special permission.

7: WATERPROOFING AND DECK SURFACING

7:1 General

The surfaces to be handled and the method of waterproofing are given on the Bridge Plan. The Standard Specifications for Waterproofing and Dampproofing shall be observed, when applicable.

As for protective concrete, only complementary directions are given in this Item. The directions given in Item 4 above shall be followed, when applicable.

In constructing asphalt surfacings, Section 17 of the General Specifications for Road Construction shall be followed, when applicable.

7:2 Applications of Bitumen

7:21 Cold Application

The purpose of cold application is to improve the adhesion of the waterproofing layer or surfacing and to increase the strength of the waterproofing layer.

Cut-back bitumen shall generally be used in cold application. In horizontal surfaces the use of bitumen emulsion may also be considered with a separate permission. Both bitumen materials shall be prepared of blown bitumen PB 85/25 or another bitumen suited to the purpose. An adhesive agent suited to concrete surfaces shall be used as an additive.

A report of the mix proportions and properties of the product and any trade mark shall be submitted for the approval of the Resident Engineer.

The quantity of cut-back bitumen or emulsion used in cold application shall be 0.3...0.5 kg/m^2. The material may be applied by spreading, brushing or spraying. Surfaces to be treated shall be clean and dry. Spreading of bitumen emulsion onto a damp concrete surface may be considered with a special permission. During warm seasons concrete surfaces shall not be treated earlier than one week after concreting. Cold application shall not be carried out without a special permission if the temperature of the structure or air is below +5°C. The cold application shall be dry before hot bitumen is spread on it.

7:22 Hot Application

In hot application bitumen PB 85/40 shall be used the spreading temperature being about 200°C. The thickness of the layer shall be as uniform as possible. The consumption of bitumen shall be at least 1.5 kg/m^2. Bitumen shall not be used excessively because it may, when flowing on exposed surfaces or collecting at some spots, be detrimental to the appearance or the strength of protective concrete. This shall especially be taken into account when work is carried out in cold when the base must be heated, if necessary.

7:3 Dampproofing

7:31 Ordinary Dampproofing

An ordinary dampproofing consists of one cold and one hot application with bitumen.

7:32 Double Dampproofing

In addition to the above there shall be another hot application.

7:4 Waterproofing and Insulation Against Water Pressure

7:41 Bitumen-Sheet Insulation

The concrete surface to be insulated shall be thoroughly levelled (Cf. 4:47 and 4:48). The angles of vertical and horizontal surfaces shall be rounded off at a radius of not less than 5 cm and the vertical corners so that bitumen sheet bends without breaking.

This type of waterproofing shall consist of the following layers (from bottom):

- cold application
- hot application
- glass fibre bitumen sheet with a type marker according to RT-card 203.941 of ML 500/4200 in which the figure 500 means the nominal weight (g/m^2) of glass fibre fabric and

the figure 4200 the nominal weight (g/m^2) of the product.

The bitumen sheet shall be pressed onto hot bitumen. The temperature of applied bitumen shall not be significantly lower than 200°C. The temperature of the fabric during spreading shall be not less than 20°C. Local heating shall be used when making sharp bends. Sheet strips shall be overlapped at least by 10 cm taking account of the direction of the flow of water. The seams shall be jointed by hot bitumen or by heating. The joints shall then be brushed once with hot bitumen.

When agreed separately, jute bitumen sheet, type marker MJ 300/4000, may be used instead of glass fibre bitumen sheet.

7:42 Insulation with Jute Fabric and Bitumen

Concrete surfaces shall be treated as set out in Item 7:41 above. Instead of rounding-off corners, sharp edges shall generally be removed.

This type of waterproofing shall consist of the following layers:

- cold application
- hot application
- jute fabric with a nominal weight of not less than 300 g/m^2
- hot application.

Jute cloth shall be pressed tightly into the underlying hot bitumen layer. The strips shall be overlapped by not less than 10 cm taking account of the flow of water. Corners, angles and bends as well as areas around outlets shall be strengthened by a 15...20 cm wide jute cloth strip glued with hot bitumen. A uniform hot application shall be the upmost layer. Bitumen shall not be used so excessively that it will flow from below the protective concrete.

Instead of jute fabric a glass fibre fabric with a nominal weight of not less than 180 g/m^2 may be used.

7:43 Other Methods

The specifications for other waterproofing systems and for insulation against water pressure are given in the Bridge Plan. When applicable, directions given above in Items 7:41 and 7:42 shall be followed.

7:5 P r o t e c t i v e C o n c r e t e

The thickness of protective concrete shall be 5 cm. Unless otherwise provided on the Bridge Plan, its reinforcement shall be tied of wires ø 6 # 15 cm/A 22 or made of welded fabric ø 5 # 15/B 50 V.

Any equivalent reinforcement may also be used.

The quality and strength category of concrete shall be BK 300.

The maximum grain size of aggregate shall be 16 mm and the percentages of material passing through sieves as follows:

# 0.125 mm	3... 5 %
1.0 "	28...32 %
4.0 "	45...55 %

The concrete mix shall contain air-entraining agent so that the quantity of entrained air mentioned in Item 4:51 shall be at least 3 % of the volume of concrete. Concrete shall be proportioned as stiff as possible, 5...10°VB and a plane vibrator shall be used in compaction.

The surface of protective concrete shall be graded by grinding with timber. The maximum permissible unevenness over a distance of 5 m is 12 mm provided that there will be no depressions collecting water. The average deviation of the surface observed by leveling from the level provided on the Plan shall not exceed ± 1 cm and the largest measured deviation not more than ± 2 cm. Water sprinkled on protective concrete shall not pond in depressions. Without a separate permission protective concrete shall at no spot be made more than 2 cm thicker than the theoretical thickness and thinner than 4 cm. The average thickness shall not be more than 1.5 cm larger than set out on the Plan.

As soon as possible after pouring the surface of protective concrete shall be protected and kept damp in accordance with Item 4:47.

7:6 Surfacing

7:61 Asphalt Surfacing of Roadway

Unless otherwise provided on the Bridge Plan or other Documents to be followed, the protective concrete shall be covered by the following surfacing courses:

1. Sealing Course

   Cold bitumen application as set out on Item 7:21 account being taken of the fact that cut-back bitumen used shall be suitable for sealing of asphalt surfacings and the consumption of the sealant 0.4...0.5 kg/m^2.

2. Binder Course

   A somewhat open asphalt concrete Ab 12...18/70 kg/m^2 or gravel asphalt concrete SAb 12...18/70 kg/m^2. Bitumen B 120 to be used as binder. The announced consumption corresponding to a layer thickness of about 3 cm.

3. Wearing Course

   As dense asphalt concrete as possible Ab 12...15/70 kg/m^2 or gravel asphalt concrete SAb 12...15/70 kg/m^2 with bitumen B 120 as binder, or sand asphalt concrete HAb/ 70 kg/m^2 with bitumen B 80 as binder. The surface of sand asphalt concrete shall be roughened by bituminous chips 12...18 (20) mm with a quantity of binder B 80 of 1.0...1.5 %. Chippings in a quantity of 6...10 kg/m^2 shall be used for roughening. The thickness of the surfacing course shall be about 3 cm.

As for the binder course Ab or SAb may be selected depending on the availability of aggregate. On high-class paved roads, the wearing course on the bridge shall generally be of the same type as on the road. Otherwise, the more advantageous alternative may be selected unless otherwise agreed.

7:62 Asphalt Surfacings for Footwalks and Bicycle Paths

The surfacing shall consist of a sealing course and a 3 cm thick wearing course to be constructed as set out in Item 7:61 above. Unless a footwalk or bicycle path has been designed for vehicle loads, the mixture shall be spread manually, and a vibrating plate, hand roller or a light static wheel roller not more than 1.5 tons in weight shall be used in compacting. In surfacing old bridges and even in other special cases the maximum permissible weight of the roller shall be determined separately for each case and mastic asphalt may also be used. The surface of sand asphalt concrete on footwalks and bicycle paths is not roughened. The surface shall be dense and smooth.

7:63 Other Surfacing Types

Should the protective concrete be covered by unbound or bound pavement courses of the road the surfacing of the road shall be carried over the bridge.

Detailed directions for surfacings other than asphalt and for all surfacings of both steel and wooden bridge decks

are given on the Bridge Plan or in other Documents to be followed.

7:64 Joints

The joints of surfacings set out on the Plan shall be filled with a sealing compound based on bitumen. It shall generally be prepared of blown bitumen PB 85/40 or PB 95/35 using asbestos or limestone powder as filler. The quantity of bitumen shall be at least 60 % of the weight of the mixture. Of the filler, 80 % shall pass through a 0.074 mm-sieve. In order to improve elasticity, approvable additives such as rubber may be used. The jointing compound shall be of uniform quality and flexible enough in a temperature of 150...200°C. Prior to pouring of the compound the joint shall be thoroughly cleaned and treated with cut-back bitumen.

Even other approvable jointing compounds may be used, provided that good results have been obtained of their use in practice.

7:7 O t h e r D i r e c t i o n s

Precautions shall be taken at all stages of waterproofing and surfacing operations against staining exposed concrete and steel surfaces with bitumen. In concrete surfaces facing the ground the dampproofing shall be ended about 10 cm below the theoretical ground level. Breaking of insulating layers during the work shall be prevented. If necessary, a thin layer of fine sand may be used as a temporary protective layer.

8: SPECIAL PARTS

8:1 Bearings and Hinges

8:11 Drawings and Materials

In general, bearings and hinges shall be made in conformance with detailed drawings appended to the Bridge Plan. For special bearings, made according to the plan of the manufacturer, information for ordering and design only will be given.

The directions and regulations for steel structures in general also apply to the materials, delivery, manufacturing, cleaning and painting of steel bearings.

The requirements for the material and construction of special bearings are generally as set out on the approval documents in the country of manufacturing. However, weather and other conditions on the bridge site shall be raken into account when the adequacy of bearings is assessed.

The bitumen felt used in hinges shall be insulating felt A No. 0 or glass fibre insulating felt with type markings as set out in RT card 203.941 are EA 500/2300 and EL 70/2000. The felt shall be glued to the base and against one another with hot bitumen. Concrete surfaces shall furthermore be treated by cold bitumen application before sealing.

8:12 Installation

Prior to the installation of bearings it shall be ensured that materials and preparation conform to the specified requirements.

In installing bearings account shall be taken of the movements of the superstructure due to the shrinkage and creep of concrete and temperature variations. In large bridges longitudinal movement may also be caused by deflections of the superstructure which shall be taken into account. In prestressed structures allowance shall also be made for elastic compression. The bearings shall be installed concentrically when the bridge is loaded by dead load and the temperature being $0^{\circ}C$.

The base plates of bearings shall not generally be grouted before the whole superstructure has been installed. In cast-in-place concrete bridges bearings shall however be normally fixed into the substructure before the superstructure is concreted. The tolerances permissible in the installation of bearings shall be considered separately for each case account being taken of any extra strains caused by the incorrect position of bearings to the bearings themselves or to other bridge structure.

Unless detailed instructions for fixing of bearings are given in the Bridge Plan, the performer of the work shall decide on the most expedient materials and methods. The approval of the Resident Engineer shall be acquired for the

suggestion. When the base plates of bearings are cast into substructures, proper steps shall be taken to ensure that the bearing base will be filled. Special grouts are recommended being easy to cast and not shrinking when hardening.

8:13 Other Directions

Installation sheets and bolts as well as other accessories must be removed as soon as possible after fixing of bearings. Care shall also be taken during the work to ensure that these devices will not obstruct the movement of the bridge.

Steel parts of bearings and hinges shall be coated twice with red lead or like. Finish coating shall also be carried out twice with paints suited to steelwork. The tint of the finish coat in steel bridges shall be the same as on other bridge structures and in concrete bridges grey or aluminium (Cf. 5:51).

Sliding and rolling surfaces shall not be painted. They shall be treated with suitable anti-corrosion lubricants.

8:2 Expansion Joints

8:21 General

The structure will be shown in Drawings. Information only for orders will be given of patented special structures.

The adequacy of materials shall be ascertained in a proper way. Unless otherwise agreed, requirements specified in Item 5:2 shall apply to steel material, when possible.

8:22 Expansion Joint Devices

Care shall be taken during installation to ensure that the functioning of the device is possible. Should it be necessary during concreting to fix the sections temporarily, they shall be absolutely taken apart before obstructing the movement of the bridge caused by shrinkage.

If the bridge is supported at the expansion joint on rubber bearings in which a significant compression can be observed as a result of the weight of the bridge, the parts of expansion joint obstructing vertical movement at the joint must not be fixed before load-carrying scaffoldings have been stripped. A part like this is the so-called cover plate or like.

Welding shall be carried out as set out in Item 5:33, when possible. Deformed bars shall not be used as dowels. Parts twisted by welding or some other reason shall be bent at the shop accurately to the shape of the bridge deck. Intermittent, plug or slot welds must not be used in fixing of parts.

Surfaces of steel parts other than those inside concrete shall be painted twice with paint based on bitumen reaction or similar paints resistant to water and salts.

Cleaning may be by wire-brushing (St 2) unless sand blasting can be arranged.

8:23 Sealing Compounds and Strips

Approvable sealing compounds and strips shall be used. In selecting materials account shall be taken, among others, of the size and speed of movement at the joint, requirements for watertightness and possibilities of maintenance. Strips made of rapidly ageing material must not be used. Sealing compounds shall adhere well to joint surfaces. In exposed concrete structures the colour of sealing compound shall be light grey. Directions for sealing of joints in pavement have been given in Item 7:64 herein.

8:24 Other Directions

Expansion joints shall generally be watertight. Care shall be taken during the work to ensure that the joint will resist anticipated movements without breaking. Such material shall be used as a form or an intermediate sheet as will not stain exposed structures owing to the moisture of concrete or sprinkling water. Fillers harmful to the appearance shall be removed.

8:3 G u a r d r a i l s

8:31 Materials and Construction

The typical drawings to be followed are mentioned in the

Bridge Plan. In the same connection, the method of surface treatment - painting or hot dip galvanizing - is also specified. The directions for steelwork (Cf. Item 5:) shall also apply to the material and manufacturing of guardrails including cleaning, painting or galvanizing. Special attention shall however be given to finishing. All sharp edges and so-called splashes from welds shall be removed by grinding.

8:32 Installation

The guardrail shall always be installed to the alignment of the road edge and grade although the structure to which the rail is to be fixed were deviating from the same (i.e. straight superstructure of the bridge in a long-radius curve). The posts shall be installed in a vertical position.

Recesses left in concrete for installation shall be protected so that water will not freeze, or they shall be fitted with outlet pipes on which a more detailed agreement shall be made with the Resident Engineer. In grouting rail posts care shall be taken to ensure that the recesses are filled and compacted so that no damage will be caused by water.

8:4 D r a i n a g e o f B r i d g e D e c k

8:41 General

Sewerage devices and superelevations of the surface of structures and any channels for water are given on the

Plans. Errors made during the work and the inaccuracy of measurements shall not result in obstructions for conveyance of water from the bridge deck.

8:42 Gulley Pots and Channels

Unless otherwise provided on the Bridge Plan cast iron pipes shall be used as gulley pots. The pipes shall be cast into load-carrying concrete structures. Concrete around the pipe shall be thoroughly compacted. The insulation shall be raised undamaged about 5 cm upwards along the pipe. The junction of asphalt surfacing and the gulley pot shall be tightened by sealing compound in conformance with Item 7:64. The joint shall be regular and about 2 cm wide. The upper surface of the gulley pot shall be about 0.5 cm lower than the surrounding asphalt surface or the bottom of the channel. The difference in height shall be levelled by the sealing compound.

The maximum permissible depth of the channel has generally been given on the Drawings. The bottom of the channel shall not be lower than the surface of the binder course of the surfacing. If the longitudinal slope fall of the bridge is at least 1 %, the depth of the channel may be held constant. If the slope fall is smaller the bottom of the channel shall be made sloping so that the most beneficial result will be achieved from the point of view of flow of water. In that case, the bottom of the channel shall rise to the surface of the wearing course between gullies.

8:43 Structural Drains

Structural drain pipes shall be placed so that the head is flush with the load-carrying concrete slab and the end below the soffit by the thickness of the form board unless other directions have been given on the Bridge Plan. Insulation shall be carried over the edges of the pipe. A cone-shaped hole shall be made in protective concrete at the pipe from which water collecting on protective concrete can be conveyed. Prior to surfacing operations a dense brass mesh shall be placed on the pipe to prevent asphalt mixture from entering the pipe. Prior to spreading of asphalt, holes shall be filled flush with the surface of protective concrete with surfacing mix poor in bitumen used in binder course, and lightly compacted.

It shall be checked during the work that no significant amounts of water will collect on the deck being conveyed away through drip pipes. If necessary, additional pipes shall be installed or other steps shall be taken to improve drainage. Drilling holes in a permanent structure shall generally be taken as a revision of the Bridge Plan.

8:5 A p p r o a c h S l a b

8:51 General

An approach slab shall be cast as late as possible so that the embankment below has already settled. Directions and requirements for filling and compacting embankment have

been given in Item 3:51 herein and in Item 1540 of the General Specifications for Road Construction.

8:52 Cast-in-place Slabs

A plastic membrane shall be spread on compacted earth. The thickness of the concrete layer protecting steel in the underside of the slab shall be not less than 3.0 m. Unless otherwise provided on the Bridge Plan the quality and strength category of concrete shall be BK 300. Concrete shall be proportioned elastic or stiff. The amount of entrained air achieved by additives shall be not less than 3 % of the volume of concrete unless otherwise agreed. Directions given in Item 4: herein shall be observed.

The approach slab shall not be cast into wing walls. The space between shall be at least 5 cm.

8:53 Prefabricated Slabs

Directions given in Item 4:9 herein shall be observed in prefabrication of slabs. The location of fixing dowels shall be checked by measuring prior to prefabrication. The base shall be levelled and compacted so that the slab is uniformly supported at all spots.

8:6 O t h e r D e v i c e s

Devices included in this Item are, among others, clamps of lighting columns, tubes, cables, channels and charge spaces.

In constructing spaces for charges directions shall be accurately observed.

The devices shall be fixed either during concreting or holes shall be reserved for later installation. In casting later on directions given in Item 4:48 shall be observed. Making additional holes and reservations not included in the Bridge Plan shall be regarded as a revision of the Plan.

Reinforcement bars in the way of holes and recesses must not be displaced or cut off without a permission of the Resident Engineer. Cut bar shall generally be replaced by additicnal bar placed next to the hole.

Recesses shall be protected against freezing of water collected therein.